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ENVIRONMENTAL CLEANUP

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April 13, 2012

<u>Sent by electronic mail and U.S. Mail</u>

Chip Humphrey, Remedial Project Manager
Oregon Operations Office
U.S. Environmental Protection Agency
805 S.W. Broadway, Suite 500
Portland, Oregon 97205

Kristine Koch, Remedial Project Manager
Office of Environmental Cleanup, ECL-115
U.S. Environmental Protection Agency
1200 Sixth Avenue, Suite 900
Seattle, Washington 98101

Re: Portland Harbor Superfund Site
Submittal of Comments on the LWG Draft Bioaccumulation Model Report

Dear Mr. Humphrey and Ms. Koch:

One of the principal drivers for establishing preliminary remediation goals (PRGs) for PCBs at the Portland Harbor Superfund Site is the characterization of the relationship between PCBs in sediments and those in target receptors, in particular smallmouth bass (SMB). To date, that relationship has been established by the July 21, 2009 Draft Bioaccumulation Model Report prepared by Windward Environmental (Windward) for the Lower Willamette Group (LWG). That report apparently has not been the subject of specific EPA written comments and, to the best of our knowledge, remains in draft form. Nevertheless, the LWG model is the basis for the focused PCB PRG of 29.5 ug/kg that the Draft Feasibility Study (FS) Report applies in developing and evaluating potential PCB Remedial Action Levels (RALs) for the site. The selected RALs will determine the river area that requires remediation. The PCB sediment PRG thus is a highly significant and foundational parameter for establishing the extent of required remediation at the Portland Harbor site.

Given its key importance, it is critical that the LWG PCB Bioaccumulation Model be constructed on sound principles and appropriately characterize the exposure of target species. FMC Corporation (FMC) and other Portland Harbor GNL recipients have specific technical reasons for concluding that the LWG model does not meet these criteria. Enclosed is a report entitled "Comments on the LWG Portland Harbor RI/FS Draft Bioaccumulation Modeling Report" dated April 2012 that has been prepared by Hanna Associates, Inc. - Integrated Risk Management (HAI-IRM), a consultant to FMC. Also enclosed is an April 4, 2012 letter from HAI-IRM transmitting this report to FMC counsel. The electronic files referenced in the report are being sent electronically with this letter rather than in hard copy. The HAI-IRM report details a number of significant shortcomings in the LWG model.

As described in the HA-IRM report, the design of the LWG model and the process used to calibrate it to observed conditions show that the model is not sufficiently robust to generate reliable and justifiable PRGs. In addition, the model used inappropriate SMB exposure assumptions in developing the 29.5 ug/kg PCB sediment PRG. The LWG model assumes that SMB exposure occurs uniformly across the width of the river channel and along the length of the RI/FS study area, despite the fact that radio-tagging data demonstrate that SMB in the study area have an approximate home range of one river mile and feed predominantly in nearshore areas. By correlating SMB tissue concentrations to the average channel-wide sediment concentration, which is significantly lower than nearshore levels, the LWG model under-estimates their PCB exposure, over-estimates their PCB bioaccumulation, and contributes to generating a PRG not supported by the site data. As the HAI-IRM report summarizes at pages 15-16, use of applicable nearshore PCB sediment data to characterize SMB exposure generates a Total PCB sediment PRG of 61.3 ug/kg even without making any of the other model corrections recommended by the report. Compared to the 29.5 ug/kg channel-wide PRG that EPA and LWG currently are using, this adjusted nearshore PRG supports selection of a less conservative RAL that would significantly reduce the river area where active remediation would be required. The magnitude of this reduction is discussed at page 16 of the enclosed report.

HAI-IRM developed an initial version of this report in July 2010, and HAI-IRM and FMC met with Windward and LWG representatives in September 2010 to discuss it. At that time it was envisioned that the report would lead to refinement of the draft LWG model. Because that further development has not occurred, and given the critical importance of establishing a scientifically justified PCB sediment PRG, FMC with the support of a number of other Portland Harbor GNL recipients is now submitting the updated report to EPA for the full evaluation that we believe it warrants. EPA consideration of this report is particularly timely in that the PCB sediment PRG has been identified as a Remediation Goal (RG) in the Draft Feasibility Study Report, where it has been applied as a key criterion in defining and evaluating a range of potential Total PCB RALs. The adjusted PRG derived in the enclosed report supports a less conservative range of Total PCB RALs and provides a more technically accurate and appropriate basis for RAL selection.

We would like to schedule a meeting with you and other technical staff to discuss this report after you have had an opportunity to review it. Please contact me at telephone 206/ 676-7030 to arrange that meeting. Thank you.

Sincerely,

David M. Heineck

David M. Heineck
Attorney for FMC Corporation

Enclosures sent in hard copy and as electronic files

cc (w/enclosures):

Daniel J. Opalski, Director, Office of Environmental Cleanup
Lori Houck Cora, Esq., Assistant Regional Counsel

hanna associates, inc.
integrated risk management

April 4, 2012

David M. Heineck
Summit Law Group, PLLC
315 5th Ave. South, Suite 1000
Seattle, Washington 98104-2682

RE: Review of LWG's Draft Bioaccumulation Modeling Report - Update
Portland Harbor Superfund Site

Dear Mr. Heineck,

As you recall, Hanna Associates – Integrated Risk Management (IRM) submitted an extensive critique of LWG's draft Bioaccumulation Model in July 2010, and met with LWG technical representatives later that year to discuss those comments. At that time it was envisioned that IRM's comments, along with those from EPA and other groups, would be used to revise the model as necessary prior to its finalization. However, to date, this review process has not occurred. Instead, the model which forms the cornerstone of the conservative Total PCB focused PRG (29.5 ppb) currently included as a Remedial Goal (RG) within the draft FS, remains unchanged.

Given the degree of uncertainty and conservatism readily apparent in the LWG's draft Bioaccumulation Model as detailed in IRM's critique, IRM has used data recently provided by LWG to perform a re-evaluation of the model to derive an alternate Total PCB PRG based on a more realistic exposure characterization. The findings of this reevaluation have been incorporated into IRM's original critique together with an analysis of the potential impact of the alternate PRG on the remedy. The additional evaluation can be reviewed beginning on page 15 through the conclusion of the comment document, and is described in greater technical detail in Attachment B.

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In short, notwithstanding the many significant shortcomings of the LWG model, IRM's amendments more realistically characterize exposure and result in an alternate PRG, and subsequently RG, that is more technically sound. Furthermore, use of the alternate PRG would result in a less conservative range of Total PCB RGs than developed in the recently submitted draft FS, that would likely require significantly less remediation. Thus, IRM's findings have the potential to favorably impact EPA's evaluation of the remedial alternatives presented in the draft FS.

If you should have any questions, please do not hesitate to call.

Regards,

Linda M. Hanna, PhD

CC: Maureen Mitchell, Summit
John Stillmun, FMC
Shawn Tollin, FMC

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Comments on the

LWG Portland Harbor RI/FS

Draft Bioaccumulation Modeling Report

Prepared for

FMC

Prepared by

hanna associates, inc.
integrated risk management

April 2012

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Figure 8: LWG Comparison of Total PCBs Site-wide SWAC to Potential RALs

Electronic File:

"Kabam Model – Recreate LWG Calibrated Model (07-30-2010).xlsx" EXCEL workbook

Attachments

Attachment A: Model Discrepancies

Attachment B: Method and Findings of Bioaccumulation Model Re-Evaluation

Attachment B Electronic Files:

Kabam Model – Amended Near-Shore Model (02-20-2012).xlsx

Kabam Model – Near-Shore PRG (02-20-2012).xlsx

Near-Shore RAL-SWAC-PRG Calculations (02-20-2012).xlsx

Near-Shore SWAC Calculation (02-20-2012).xlsx

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LWG Versus Amended Model Small Scale Performance (02-20-2012).xlsx

Introduction

The following comments are with regard to the Portland Harbor Draft Remedial Investigation/Feasibility Study (RI/FS) Draft Bioaccumulation Modeling Report, prepared for the Lower Willamette Group (LWG) by Windward Environmental LLC, dated July 21, 2009 (hereafter referred to as the LWG Bioaccumulation Model [Windward, 2009a]). These comments, excluding the "Model Re-Evaluation Using Near-Shore Concentrations" section and Attachment B, were originally submitted to LWG on August 13, 2010. The model re-evaluation was performed following receipt in October 2011 of GIS data from LWG that was needed to characterize near-shore sediment concentrations.

The LWG Bioaccumulation Model, which is based on the Arnot and Gobas (2004) food web model (FWM), has been used by LWG to develop preliminary remediation goals (PRGs) which, in turn, have been used to identify areas of potential concern (AOPCs) in the RI. Ultimately, LWG envisions that the Bioaccumulation Model will be used, in conjunction with fate and transport models, to evaluate different remedial options in the FS. Thus, the Bioaccumulation Model is a critical component of the Portland Harbor RI/FS.

While multiple chemicals of concern (COCs) and receptor species are addressed in the report, LWG prioritizes the model's predictive ability for total PCBs in smallmouth bass (SMB), because total PCBs were identified as a major contributor to risk in both the draft Baseline Ecological Risk Assessment (Windward, 2009b) and the draft Baseline Human Health Risk Assessment (Kennedy/Jenks, 2009), and because of the importance of SMB for PRG development and ultimately remediation decisions. Indeed, several steps in the model calibration are specifically focused upon optimizing the model's predictive performance for this combination of COC and receptor. Consequently, these comments on the LWG Bioaccumulation Model are also primarily focused upon the model's ability to reliably predict the relationship between PCB concentrations in sediment and SMB tissue.

Comments on the LWG Bioaccumulation Model are divided into several categories. Initially, general comments regarding the Bioaccumulation Model and its applicability to the Portland Harbor site are provided. Comments regarding the model calibration process and calibrated model performance are then provided. These comments illustrate deficiencies in the model and its applicability for deriving meaningful PRGs. The degree of uncertainty in the LWG model is further highlighted by derivation of an alternate total PCB PRG for human consumption of SMB using a revised version of the model that more realistically characterizes exposure. Finally, comments regarding discrepancies between assumptions in the calibrated model versus other Portland Harbor RI documents and the Arnot and Gobas (2004) FWM are noted in Attachment A, and a detailed description of the methods and findings of the model re-evaluation is provided in Attachment B.

Based on the evidence presented herein, the LWG Bioaccumulation Model is considered to be seriously flawed and biased towards the development of overly conservative PRGs for total PCBs, the risk-driving COC at Portland Harbor. Given the importance of the Bioaccumulation Model within the RI/FS process it is requested that the following comments be taken into fuil consideration during revision and finalization of the Bioaccumulation Model. If there is no intention to finalize the Bioaccumulation Model report, as now appears to be the case, these comments along with the alternate PRG derived in this review should be used to better inform remedial alternatives and risk management decisions.

General Comments

1. Applicability of Steady-State Bioaccumulation Model to LWR

   The Amot and Gobas (2004) FWM, upon which the LWG Bioaccumulation Model is based, is a fugacity model which assumes that the aquatic system is in steady state with respect to bioaccumulation of hydrophobic organic chemicals. LWG states that the overall goal of the mechanistic modeling was to develop predictive relationships between chemical concentrations in sediment, water, and tissue, both now and under a variety of prospective remedial action scenarios. However, the applicability of this model to a highly dynamic system with many source variables is unclear, especially for COCs that are subject to relatively slow exchange kinetics (e.g., substances with higher octanol-water partition coefficients (Kow) [such as PCBs] in higher trophic level receptors [such as SMB]), because steady-state takes a long time to achieve (over a year in the case of PCBs).

   To elaborate on this concern, while the Bioaccumulation Model treats water and sediment concentrations as inputs, it does not model the abiotic fate and transport processes that govern the sediment and water concentrations within this highly dynamic system. Consequently, characterizing the relative contribution of in-place sediment concentrations versus other sources to tissue concentrations is an important consideration within the FS. It is understood that LWG is in the process of developing a hybrid fate and transport/Bioaccumulation Model for the FS, which will link a time dependent fate and transport model (QEAFATE) to the finalized Bioaccumulation Model. While details of this process are not available, there are technical concerns with the concept of linking a time dependent fate and transport model to the steady-state Bioaccumulation Model, particularly when it is estimated that steady-state would not be achieved for the COC and receptor of primary concem (PCBs/SMB) for over a year under future, post-remedial conditions.

2. Lack of Transparency in Model Documentation

Despite the voluminous nature of the LWG draft report, documentation of the Bioaccumulation Model is not transparent and, as described in Attachment A, internal model discrepancies, as well as discrepancies between the LWG model and that of Amot and Gobas (2004), were noted. While a hard copy of the model code was provided in Appendix E, an electronic copy of the calibrated model code, including all parameter input values and model output, would have greatly enhanced the ability of reviewers to evaluate and verify the model.

In spite of the lack of transparency, reproduction of LWG's calibrated model output, specifically the Species Predictive Accuracy Factors (SPAFs) which are derived as the ratio of the model predicted tissue concentration to the empirical data, was achieved using a modified version of EPA's Microsoft EXCEL Kow Based Aquatic BioAccumulation Model (KABAM) (Version 1.0 – April, 2009). This EPA model is also based on the Amot and Gobas (2004) FWM. The modified KABAM model is provided with these comments in the attached "Kabam Model – Recreate LWG Calibrated Model (07-30-2010).xlsx" EXCEL workbook. In the absence of LWG's original model and input files, this recreation of the calibrated model results for total PCBs was used as the basis for quantitatively evaluating the significance of uncertainties within the LWG modeling approach, as described below.

Model Calibration

The approach used to calibrate the LWG Bioaccumulation Model is summarized in Figure 5-1 of the draft report (recreated herein as Figure 1). As shown in this figure, the calibration process was divided into two sequential efforts. Initially, non-chemical-specific parameters were calibrated. Chemical-specific parameters were subsequently calibrated.

While a narrative description of the calibration process was provided in the report, a comprehensive review could not be performed because LWG did not include an electronic copy of the probabilistic model used to perform this task. In addition, output from the calibration mns were not provided in sufficient detail to understand the degree to which altemate parameter characterizations resulted in similar model performance. Nonetheless, as discussed further below, it is concluded that the calibration process did not result in a final model that is sufficiently robust to develop reliable PRGs. Moreover, several of the assumptions incorporated into the calibration process are clearly biased toward an overly conservative characterization of the relationship between sediment and tissue concentrations, particularly for SMB, resulting in the identification of low-biased, overly burdensome sediment PRGs.

The comments below provide a critique of the sequential calibration process, with emphasis on characterization of the highly sensitive Kow input parameter (Comment 6). In addition, Comments 7 and 8 are considered the most critical in developing PRGs in that they call into question the method LWG used to characterize sediment exposure concentrations for SMB, which ultimately dictates the relationship between sediment and tissue concentrations in the calibrated model.

3. <u>Consideration of Parameter Plausibility in Model Optimization</u>

The entire calibration process was geared towards predicting current conditions. Plausibility of the resulting parameter values was not appropriately considered. Consequently, the 'optimum ruodel parameters' case chosen to represent site conditions is questionable. For example, as a result of the calibration, the diet of benthic invertebrate consumers (i.e., oligochaetes, insect larvae, and amphipods) is assumed to be comprised of 91% sediment and 9% zooplankton. This diet does not seem appropriate based on the infaunal corumunity structure and diet as described in the draft BERA (Windward, 2009b). Model optimization without consideration of plausibility does not guarantee prediction under differing conditions.

4. <u>Poor Structuring of Probabilistic Non-Chemical-Specific Calibration</u>

50,000 model runs were performed as part of the initial probabilistic non-chemical-specific calibration (pg. 38). However, according to LWG, a screening step performed on the output determined that over 40,018 of these runs resulted in parameter values that fell outside of pre-defined acceptable ranges (pg. 47). Thus, less than 20% of the model runs could be used to identify the combinations of input parameters that best approxiruated the empirical data. It is unclear why the probabilistic model was not structured in such a way that output resulting in parameter values outside pre-defined acceptable ranges was not immediately rejected, and the distributions automatically re-sampled within the probabilistic simulation. In this manner, the target number of model runs (50,000) would have been available to identify the combinations of input parameters that best match the data.

5. <u>Poor Perforruance of Probabilistic Non-Chemical-Specific Calibration</u>

LWG indicates that SPAFs, derived as the ratio of the model predicted tissue concentration to the empirical data, comprise the primary model evaluation metric. Of the 50,000 initial non-chemical-specific calibration runs, reportedly only 842 (~ 1.7%) resulted in a Study Area-wide SPAF of less than 1.5 for SMB. Moreover, page 47 of the draft report implies that only 25 of these 842 model runs also met the target criteria of a SPAF less than 5 for carp, SPAFs less than 3 for other fish species, and SPAFs less than

5 for invertebrates. If this interpretation of the report is correct, the inability to perform the 50,000 probabilistic model mns within the pre-defined acceptable parameter value ranges resulted in an insufficient number of model mns to achieve a robust initial calibration (i.e., to obtain a larger sub-set of mns that met LWG's target criteria).

6. Characterization and Calibration of Octanol-Water Partition Coefficient (Kow)

In EPA's sensitivity analysis of the KABAM model parameters, nearly 75% of the model output variability was attributed to the chemical-specific octanol-water partition coefficient (Kow). LWG acknowledges in the draft report that the model is "highly sensitive" to Kow. As documented in Table 5-4 of the LWG Bioaccumulation Report, the initial 50,000 probabilistic non-chemical-specific calibration model runs were performed using a uniform distribution to characterize the Log Kow for total PCBs, with this distribution ranging from 6.09 to 7.84 (Table 5-4). In prior responses to EPA comments questioning the suitability of using a steady-state model for COCs with high Kow values, LWG stated that EPA's concem is incorrect and that "The Gobas type models have been developed for hydrophobic chemicals which, by definition, have relatively high Kows" (1st comment/response of pg. 7 of LWG, 2009). However, Amot and Gobas (2004) specifically note that the model "... should be used with caution when the exchange kinetics are relatively slow (e.g., slowly metabolizable chemicals of high Kow (i.e., $>10^{7.5}$) in large, lipid-rich organisms." Assuming the cited Log Kow distribution was indeed sampled uniformly, nearly 20% of the initial probabilistic calibration mns incorporated a Log Kow in excess of this cautionary threshold.

In addition to the above, it is noteworthy that over 97% of the initial Log Kow uniform distribution is greater than the Log Kow for total PCBs incorporated into the final calibrated model (calibrated Log Kow = 6.14 per Table 5-12). Thus, the Total PCB Log Kow distribution used in the initial calibration is biased high and, presumably, biases the calibration of the non-chemical specific parameters (including environmental parameters such as temperature and dissolved organic carbon, and biologic parameters such as dietary parameters and species water content). This issue appears to have been overlooked within the LWG model development as no justification for this approach was provided

7. Mischaracterization of SMB Exposure

In the Study Area-wide calibration, the total PCB sediment concentration was held at a constant value of 92.6 µg/kg dw (Table 5-3). LWG reports that this concentration is representative of the spatially weighted average concentration (SWAC) of total PCBs in surface sediments in the Study Area, based on the BERA dataset for river mile (RM) 1.9 to 11.8.

Given that the objective of the model is to express the relationship of a COC concentration in media to which receptors are exposed (sediment, water and prey), clearly the total PCB sediment concentration incorporated into the model should be representative of the sediment concentration to which the receptor of concem is actually exposed. The LWG report concurs with this objective stating "The Study Area-wide SWAC was assumed to represent the average sediment exposure condition for the sampled organisms (pg 42)." LWG also caveats that using Study Area-wide SWACs "...could be a source of error for small-home-range species collected from areas of known or suspected sediment contamination (e.g., crayfish) because the Study Area-wide SWAC might underestimate the average sediment exposure condition for the sampled organisms (which would result in an overestimation of bioaccumulation and conservatively biased PRGs for that species) (pg 42)." However, LWG makes no mention of another similar issue – preferred receptor habitat across the width of the river channel (e.g., preference for near shore versus navigational channel environment).

The Study Area-wide sediment SWAC is based on the average concentration between RM 1.9 and 11.8 across the entire width of the river. However, as shown in Figure 5-18 of the LWG report (recreated as Figure 2 herein), total PCB concentrations in composite SMB tissue samples vary depending upon which shoreline the fish were collected. As shown in this figure, differences in total PCB SMB tissue concentrations between east and west shorelines (denoted by an E or W beside the sample name) can be substantial for samples collected in the same river mile. As previously noted in LWG responses to regulatory comments on the May 29, 2009 version of the draft report (LWG, 2009), this finding is not unexpected given that SMB primarily feed near the shoreline. In fact, a study conducted from 2000 to 2003 found SMB in the Lower Willamette River (LWR) were located a median percentage of 12% from either shore (at a median distance of 33 m) (Pribyl et al., 2005).

Thus, the LWG calibration process, which LWG reports was specifically focused upon optimizing model performance for predicting SMB tissue concentrations, incorporated a total PCB sediment concentration that is not representative of actual SMB sediment-related exposure. To further evaluate the potential significance of this issue, near shore versus channel-wide[1] sediment concentrations for the Study Area were reviewed. LWG did not originally provide the GIS file used to calculate the natural neighbor Study Area-wide sediment SWACs used in the LWG model, so near shore sediment SWACs could not be developed from the same data set. However, the following GIS shape files were obtained from LWG's portal website

[1] Throughout this document, the term "channel-wide" refers to the width of the river on a bank-to-bank basis.

(https://portal.webpe.com/portal/page/portal/LWG/LWG_PUBLIC) and used to estimate the near shore and whole channel total PCB SWACs for the Study Area:

> Total PCB SWACs.shp – Contains total PCB sediment SWACs for the whole river width from RM 1.9 to RM 11.

> tPCBs_SWAC_smbass.shp – Contains total PCB sediment SWACs for shoreline areas (i.e., excludes the navigation channel) from RM 1.9 to RM 11.

The Study Area sediment SWAC for the whole channel, based on data in the 'Total PCB SWAC.shp' file, is 72.1 μg/kg (22% lower than the 92.6 μg/kg cited by LWG). Without access to the LWG SWAC file, the reason for this discrepancy cannot be determined, though it is likely related to the fact that the available SWAC data does not extend to RM 11.8. This supposition is supported by Figure 2, recreated from LWG's Bioaccumulation Model Report, which shows that the LWG mean sediment SWAC and measured SMB concentrations in RM 11 are significantly higher than the remainder of the Study Area. If correct, the sediment level in 8% of the Study Area (0.8 miles of 9.9 miles) increases the overall Study Area mean concentration by over 22%. This degree of heterogeneity in the LWR further calls into question the validity of LWG's Study Area-wide approach to modeling the LWR.

In contrast to the channel-wide SWAC, the Study Area SWAC for near shore sediments from RM 1.9 to RM 11 (i.e., again excluding RM 11-11.8), based on data in the 'tPCBs_SWAC_smbass.shp' file, is 106.6 μg/kg (48% higher than the equivalent channel-wide Study Area SWAC). Figure 3, created from LWG's shape file, graphically depicts the total PCB surface sediment SWAC data, and highlights that the near shore sediment concentrations tend to be substantially higher than in the navigation channel.

In response to a previous regulatory comment on the May 29, 2009 version of the bioaccumulation report regarding SMB preferred habitat being located near shore, LWG responded (1st comment/response on pg. 2 of LWG, 2009):

> "The comment is correct about there being differences between the east and west sides of the river. The exposure areas for which the PRGs are to be achieved are bank-to-bank, which is why we focused on bank-to-bank SWACs in the figures. The comment is also correct that the SWACs do include the river channel and it is reasonable to suppose that smallmouth bass and their prey are more exposed to PCBs from off-channel sediments than from channel sediments. The model doesn't account for that."

Also, the revised July 2009 draft report also states (pg. 42):

> "Uncertainties surrounding estimates of the baseline (current conditions) SWAC would also apply to alternative conditions (such as PRGs or estimates of post-remediation SWACs) provided they all are calculated consistently (i.e., based on the same natural neighbors interpolation method). This does not mean that sediment concentration uncertainty can be ignored, but it reduces the importance of this uncertainty in the model."

Through the above quotes, LWG appears to be arguing that bank-to-bank SWACs were incorporated into the model because PRGs are to be achieved on a bank-to-bank basis, and that uncertainties in using this approach to characterize the baseline SWAC are minimal provided the post-remediation SWAC is calculated consistently (i.e., across the river channel from bank-to-bank). This position is considered to be fundamentally flawed.

The stated objective of the model is to develop predictive relationships between chemical concentrations in sediment, water, and tissue, both now and under a variety of prospective remedial action scenarios. Clearly, that objective is not possible when low concentrations in navigation channel sediments, to which SMB are <u>not</u> significantly exposed, are used to characterize the sediment exposure concentration (and concentrations in prey). This issue is critical because the Bioaccumulation Model is essentially being calibrated to accurately predict measured tissue concentrations from low-biased sediment exposure concentrations. Consequently, PRGs estimated using the calibrated model will also be low-biased, resulting in the overestimation of areas of potential concern, and likely unnecessarily increasing remedial action costs.

In summary, while using the Study Area-wide near shore sediment SWAC would not distinguish between east and west bank sediment concentrations, or incorporate the smaller spatial scale of SMB habitat (i.e., approximately 1 mile), it would result in a Study Area-wide calibrated model that more accurately characterizes the relationship between SMB sediment exposure and tissue concentrations than the approach taken by LWG.

8. <u>Inappropriate Verification of Calibration on Spatial Scale Specific to SMB Exposure</u>

As documented in Comment 7 above, LWG acknowledges that use of the Study Area-wide SWAC to represent the average sediment concentration could underestimate the average exposure for small home range species, thereby overestimating bioaccumulation and, in turn, generating a low-biased PRG. For this reason, LWG stresses that model calibration was verified on a smaller spatial scale for SMB (1-mile average) as a secondary step in the non-chemical-specific calibration process, to ensure that the model was able to predict both on a Study Area-wide basis and in a one-mile exposure area corresponding to the assumed home range for this sensitive receptor.

To evaluate the model's ability to predict on a smaller spatial scale for individual SMB composite samples, the input sediment SWAC was amended (in fact, multiple SWACs were developed based on calculated up- and downstream 1-RM average sediment concentrations in the vicinity of each fish comprising an individual SMB composite sample) and the model output compared to corresponding SMB tissue data. LWG reviewed the output and determined that the model, calibrated on a site-wide basis, required no further adjustments since it was deemed "fully calibrated" on the smaller spatial scale based on the following rationale:

1) The use of calibrated non-chemical-specific parameters in the model resulted in improved average SPAFs for individual SMB composite samples, versus use of uncalibrated parameter values, and

2) The number of samples with SPAFs < 5 and < 10 increased when the calibrated parameter set was used.

LWG's rationale is insufficient justification to judge the model calibration. The finding that model performance improves with use of the calibrated versus non-calibrated parameters is in fact expected and, therefore, provides no basis upon which to conclude that the model was "fully calibrated". Instead, the model's ability to reliably predict tissue concentrations should form the basis for judging the model's calibration.

Recalling that the SMB SPAF for the Site Area-wide initial probabilistic calibration was required to be less than 1.5, Table 5-7 of LWG's Bioaccumulation Model Report illustrates that the average SPAF for the 32 1-mile sediment SWAC estimates was nearly 4 (i.e., on average the predicted total PCB concentration in SMB tissue was 4 times different from the corresponding measured concentration). Moreover, one-third of the individual SMB samples were associated with a SPAF greater than 5. Thus, the model's performance over a spatial scale (1-mile) that is directly relevant to the assumed home range of SMB, the receptor supposedly of primary concem to LWG, is significantly worse than the model's performance over the entire Study Area, which does not correspond to SMB home range.

Similar to the discussion in Comment 7, 1-mile average sediment SWACs were derived by LWG without consideration for the fact that SMB prefer near shore habitat. This oversight likely contributed to the poor model performance. It is also worth noting that no evaluation was performed to determine whether local conditions for sensitive model parameters (e.g., water temperature, PCB congener composition [which affects Kow], etc.) varied from those used to calibrate these parameters for the entire Study Area.

Local differences in these factors, in addition to sediment concentration, have the potential to affect local fish tissue concentrations; however, this potential complicating factor was ignored in the evaluation of smaller spatial scale model performance.

Calibrated Model Performance

The previous comments on the calibration process call into question the approach taken by LWG to establish the relationship between SMB sediment exposure and resulting tissue concentrations. However, based on an evaluation of the calibrated model performance on both a Study Area-wide basis and on smaller spatial scales (for both SMB and sculpin), LWG concluded that "the Bioaccumulation Model presented in this report is suitable and reliable for calculating sediment PRGs for the LWR." As discussed in detail below, this conclusion is not supported. In fact, as illustrated below, the model is overly conservative, resulting in low-biased PRGs.

9. Study-Area Wide Model Performance

In the Study Area-wide evaluation, LWG initially noted the low SPAFs achieved during model calibration (e.g., SMB SPAF < 1.5 for total PCBs). To further evaluate performance on a Study Area-wide basis, model-predicted tissue concentrations were graphed along with the full empirical tissue dataset for each species, and the empirical mean and medians of the empirical data. Figure 5-2, recreated herein as Figure 4, displays the predicted results and empirical data for total PCBs. LWG subsequently concluded that the calibrated model's performance is "good overall" on a Study Area-wide basis, based on the following observations:

- SPAFs are generally low and there is no pattern of significant over- or underprediction,
- Model-predicted tissue concentrations are similar to the average empirical tissue concentrations, and
- Model-predicted tissue concentrations are within the range of empirical data collected from the LWR.

LWG's observations are not disputed, however, they are wholly insufficient to conclude that the Study-Area wide model performance is good, particularly with regard to total PCBs and SMB. As discussed in Comment 7, LWG's Study Area-wide calibration primarily focused upon establishing a relationship between a significantly low-biased total PCB sediment exposure concentration for SMB (i.e., by including the navigation channel concentrations) and the Study Area average total PCB concentration in SMB tissue. The fact that LWG's calibrated model based upon this low-biased sediment concentration closely predicts the average SMB tissue concentration does not mean that the model is accurately characterizing the relationship of SMB sediment exposure and resulting SMB tissue concentrations. In fact, it is fully anticipated that the Study Area wide model could be re-calibrated to perform to the same degree of accuracy for SMB using a very wide range of assumed Study Area-wide sediment concentrations (including much higher concentrations more representative of near shore exposure).

Ultimately, however, the ability of any Study Area-wide model to reliably predict the mean or median empirical SMB tissue concentration across the Study Area is irrelevant due to the fact that it does not accurately portray exposure over the much smaller home range (approximately 1-mile) of SMB, particularly given the heterogeneous nature of conditions across the Study Area. This point is typified by the fact that the individual empirical tissue concentrations, shown in Figure 4, vary widely (110 to 6,600 μg/kg). Thus, the model's ability to reliably predict tissue concentrations in individual SMB composite samples is the only technically justifiable basis for judging the calibrated model's performance. Moreover, only if performance is good on the smaller spatial scale, should the calibrated model be considered suitable and reliable for calculating PRGs for SMB.

10. <u>SMB Spatial Scale Model Performance</u>

Figure 5-18 (recreated herein as Figure 2) presents LWG's calibrated model predictions for total PCBs in each composite SMB sample, along with the empirical data. LWG states that this figure shows that the mechanistic model generally predicts the empirical data within a factor of 3 when the mean sediment SWAC associated with each composite SMB sample is entered into the calibrated model. LWG also notes that locations where the model does not predict as well based on the mean sediment SWAC are generally areas with high variability in sediment levels and, thus, a high degree of uncertainty in the sediment concentration to which the SMB in that area were exposed. The uncertainty about these model predictions are represented on Figure 5-18 (Figure 2 herein) by error bars calculated based on the minimum and maximum 1-RM sediment SWACs that could be applicable to the individual fish within a SMB composite sample. Because the error bars generally overlap the empirical data for the SMB composite samples, LWG concludes that the model is predicting well on a smaller spatial scale.

Similar to the Study Area-wide evaluation, the above lines of evidence are not considered sufficient to reach the conclusion made by LWG. Specifically, in evaluating model performance, LWG fails to note the following:

- Model performance on the spatial scale directly applicable to the home range of SMB is significantly worse (i.e., higher SPAFs) than that of the Study Area-wide model,

- The model systematically overpredicts SMB tissue concentrations for samples in which relatively low levels of PCBs were detected,

- The model systematically underpredicts SMB tissue concentrations for samples in which relatively high levels of PCBs were detected, and

- The model fails to identify the often significant differences in tissue concentrations for SMB caught on the east bank versus the west bank in the same river mile.

Because model calibration was primarily focused on replicating Study Area average concentrations (smaller spatial scale evaluation in the calibration process was a secondary effort), the calibrated model is incapable of disceming the variability in SMB tissue concentrations. Instead, the model was constmcted in a manner that produces predictions that "smooth out" the tme variability in local SMB sediment exposure and corresponding tissue levels. This likely accounts for why the model appears constrained, i.e. systematically overpredicting SMB tissue concentrations for samples in which relatively low levels of PCBs were detected, while underpredicting SMB tissue concentrations at relatively high PCB sediment concentrations. The "smoothing" of model predictions is further exacerbated by the use of 1-mile sediment SWACs applicable to the whole channel width, rather than bank-specific near shore area SWACs more relevant to SMB exposure. As a combined result of the above formulation issues, model performance on the smaller spatial scale relevant to SMB is inferior to performance of the model on a Study Area-wide basis.

In summary, the mischaracterization of the SWAC by incorporating mid-channel sediment concentrations together with the calibrated model's systematic overprediction of total PCB tissue levels at low sediment levels is highly problematic because, as a consequence, it is structured to estimate a low-biased sediment PRG as being associated with the SMB tissue level of concem.

11. <u>Comparison of Sediment Exposure and SMB Tissue Concentrations</u>

As previously discussed, it is contended herein that river bank-specific, near shore sediment SWACs provide the best characterization of SMB exposure. To further evaluate the significance of the characterization of sediment exposure concentration on predicted SMB tissue levels, bank-specific, near shore sediment SWACs were developed from the data in the 'tPCBs_SWAC_smbass.shp' GIS shape file, and compared to both the LWG 1-mile mean SWACs and the empirical SMB tissue data.

To develop the concentration estimates, near shore (i.e., non-navigation channel) polygons representing natural neighbor sediment concentration estimates in the GIS shape file were identified for each composite SMB sample. This was done by identifying all polygons within the area that individual SMB comprising a composite sample were collected, along with polygons located one-half mile upstream and downstream of the most upstream and downstream locations at which individual fish were collected (the individual SMB sample locations were obtained from Map 4-11 of the draft BERA [Windward, 2009b]). While this approach does not match that used by LWG to develop its 1-mile, SMB composite sample-specific sediment SWACs, it was significantly less labor intensive and is considered reasonable for this screening comparison.

Bank-specific, near shore sediment SWACs were developed for each of the composite SMB samples that were collected adjacent to a specific bank within the area covered by the GIS shape file (RM-1.9 to RM-11). Thus, near shore sediment SWACs were developed for the following 20 SMB composite tissue samples (where E denotes east and W denotes west): SB02E, SB03E, SB03W, SB04E, SB04W, 05R006(E), SB05W, 06R024(E), SB06E, SB06W, SB07E, SB07W, SB08E, SB08W, 09R006(W), SB09E, SB09W, SB010E, SB010W and 08R010(SI).

To compare trends in the resulting near shore sediment SWACs to trends in both the LWG channel-wide SWACs and the SMB tissue concentrations, each data set was normalized by the highest concentration within that data set. In each case this highest concentration was associated with the SMB composite sample location at Swan Island (08R010(SI)).

As shown in Figure 5, both the heterogeneity and the overall trends in the normalized near shore sediment SWAC estimates more closely mirror the normalized SMB tissue concentrations than the normalized LWG channel-wide sediment SWACs. By contrast, the normalized LWG channel-wide sediment SWACs are "smoothed out", as discussed in the previous section (i.e. "SMB Spatial Scale Model Performance") and documented in Figure 2 herein.

While the near shore sediment SWAC estimates more reasonably characterize trends in SMB tissue concentrations, it can be seen in Figure 5 that there are anomalies between the relative magnitude of several near shore sediment SWACs and corresponding SMB tissue concentrations. In particular, normalized near shore sediment SWACs on the western shore from RM-7 to RM-9 are significantly larger than the corresponding normalized SMB tissue concentrations. As discussed below, there are multiple potential explanations for these and other observed anomalies, each one of which has the potential to complicate calibrating the Bioaccumulation Model to reliably predict SMB tissue concentrations:

a. Treatment of Non-Detects

Page 9 of the Bioaccumulation Modeling Report indicates that the highest detection limit was used to characterize the Total PCB concentration in samples in which no analytes (congeners or Aroclors) were detected. However, page 15 of the report indicates that "For geographic information system mapping, surface sediment concentrations qualified as non-detects were assigned one-half the reporting limit (RL) value". Given that sediment SWACs entered into the model were reportedly generated by natural neighbor interpolations within GIS, these two statements contradict each other. As previously discussed, the report did not provide the sediment data or GIS files used to derive the sediment SWACs, so the treatment of non-detects could not be verified. However, in either case, uncertainty associated with the actual PCB concentration in non-detect samples with high RLs has the potential to significantly bias the estimated sediment exposure concentration. For example, several non-detect sediment samples located in the vicinity of SMB composite sample SB07W are characterized by RLs (or one-half RLs) of over 1,000 μg/kg. If the actual PCB concentration in these areas is significantly lower, incorporation of such high non-detect values has the potential to significantly overestimate the sediment SWAC.

b. Characterization of Other Model Parameters

As discussed in Comment 8, local conditions for other sensitive model parameters (e.g., water temperature, PCB congener composition [which affects Kow], etc.) may vary from those used to calibrate the model for the entire Study Area. Local differences in these factors also have the potential to affect local fish tissue concentrations. For example, Figure 6 (recreated from Figure 5.1-35c of the Draft RI Report [Integral, 2009]) illustrates that the PCB homolog pattem in sediments within the area that the RM-9 SMB tissue samples were collected (centered on RM-8.8) has the lowest chlorination pattem, a pattem that is also seen in the sediment aroclor distribution shown in Figure 7 (recreated from Figures 5.1-37 f, g and h of the Draft RI Report). Dominated by tri- and tetra-chlorinated biphenyls, as shown in Figure 6, the Kow associated with the sediments in this area would be lower thereby resulting in less bioaccumulation and lower fish tissue levels, as is observed in the empirical fish tissue data.

c. SMB Home Range

As acknowledged by LWG (page 99), "... much uncertainty exists regarding the tme sediment exposure concentration. First, although the catch location for each individual fish was recorded, that location was not necessarily representative of the home range of that fish. This was especially true for smallmouth bass, which were assumed to have a home range equal to 1 RM; any given fish could have been at the southeast end of its home range, the northwest end, or anywhere in between when captured." Thus, even after amending the SWACs to account for near shore exposure, considerable uncertainty remains in the characterization of SMB sediment exposure. Moreover, the assumption of a 1 RM home range for SMB is questionable. In their study of resident piscivorous fish in the LWR, Pribyl et al. (2005) note that the median of the maximum distance SMB traveled from their location at least one month after release was only 0.4 km (0.25 miles).

Model Reevaluation Using Near-Shore Concentrations

Although the LWG Bioaccumulation Model characterizes sediment exposure on a Study Area-wide basis, efforts were made to evaluate SMB model performance on a smaller spatial scale (1 mile) which is consistent with EPA's intent to apply the PRG for human consumption of SMB on a 1 RM basis. The basis of this spatial scale is the radio-tagging data reported in the Pribyl et al. (2005) study that show the median home range of SMB in the LWR to be between 0.25 and 1.4 miles. However, despite the fact that the same radio-tagging data demonstrate that SMB in the LWR prefer the near-shore environment (median percentage of 12% from either shore - equivalent to a median distance of 33 m), no effort was made to appropriately account for this exposure in the model.

To further explore this issue, FMC requested and received from LWG the interpolated Total PCB dataset used to characterize the channel-wide Total PCB SWAC for the Study Area in the calibrated Bioaccumulation Model. A comprehensive description of how these data were used to revise the model in order to evaluate SMB exposure on a near shore-basis, and to develop and analyze the significance of an altemate near-shore PRG, is provided in Attachment B. The following provides a summary of the methods and findings.

To develop an exposure concentration for input to the model, the LWG dataset was initially queried in order to derive a sediment SWAC for near-shore portions of the Study Area (i.e., a Total PCB SWAC for sediments on the east and west banks of the LWR and within Swan Island Lagoon). The resulting near-shore Study Area SWAC, 144.3 ug/kg, was then used in place of LWG's channel-wide Study Area SWAC (92.6 ug/kg) to characterize the sediment concentration in the EXCEL file developed by FMC to recreate the Bioaccmnulation Model developed by LWG.

FMC did not perform a re-calibration of the amended model because this evaluation is simply intended to illustrate the potential significance of LWG's exposure mischaracterization. Moreover, as a third-party to the RI/FS process, with other fundamental concerns regarding the validity of LWG's overall modeling approach, expenditure of the significant resources necessary to perform such an exercise was deemed beyond the scope of this review. Instead, only the most sensitive parameter, the Total PCB octanol-water partition coefficient (Log Kow), was adjusted such that the model accurately predicted the mean tissue concentration detected in SMB samples collected throughout the Study Area. No other adjustments to the LWG calibrated model input parameters were made.

As shown in Table 1, amending the LWG model to more accurately characterize the exposure of SMB resulted in equivalent (if not better) overall model performance, as measured by SPAFs for other target species. Moreover, as discussed in greater detail in Attachment B, the amended model is better able to predict Total PCB tissue concentrations measured in individual SMB composite samples collected from the near-shore of specific river miles during the RI (i.e., the amended model performs better on the spatial scale applicable to SMB home range).

While it is FMC's position that modeling SMB exposure across the entire Study Area is not the optimum technical approach, the fact that FMC's amended exposure characterization more accurately characterizes SMB exposure, and results in equivalent predictive performance to LWG's calibrated model for other species, indicates that it is better suited to deriving a Total PCB PRG. Consequently, using the same scenario used by LWG to derive the channel-wide PRG of 29.5 ug/kg (i.e., the concentration that would result in a SMB tissue concentration protective of human fishers at a 1x10-4 excess cancer risk), the amended model was used to determine a corresponding near-shore Total PCB sediment PRG of 61.3 ug/kg.

To understand the potential impact of the near-shore PRG on the Feasibility Study (FS), FMC evaluated the degree to which near-shore SWACs exceed this target threshold. This analysis was performed under both baseline conditions and using several of the potential Remedial Action Levels (RALs) currently under consideration in the FS. To perform the evaluation, FMC used a Total PCB dataset provided by LWG that reportedly was used in the Baseline Ecological Risk Assessment (BERA) and that the LWG subsequently supplemented to include more recent data collected for the FS. FMC used an interpolated, hybrid version of this dataset (i.e., Total PCB concentrations characterized by a hybrid of both PCB aroclor and congener data). In Table 2, the results of this evaluation are presented and compared to those associated with LWG's channel-wide PRG.

As shown in Table 2A, a RAL of 1,000 ug/kg would result in a near-shore Study Area-wide Total PCB SWAC below the near-shore PRG that we have derived. Similarly, with the exception of River Mile 9-10 and Swan Island Lagoon, near-shore Total PCB 1-mile SWACs in River Miles 2 through 11 would be below the PRG. Total PCB RALs of 500 and 200 ug/kg would be required to achieve this near-shore PRG in RM 9-10 and Swan Island Lagoon, respectively[2]. Assuming that a RAL necessary to reduce the Study Area SWAC below the near-shore PRG was adopted (i.e., 1,000 ug/kg), a total of approximately 23 acres would require active remediation in the Study Area.

In contrast, as shown in Table 2B, LWG is currently projecting that a RAL of 100 ug/kg would be required to reduce the Study Area SWAC to less than the LWG Bioaccumulation Model-derived, channel-wide PRG (29.5 ug/kg). In contrast to the relatively small area (~ 23 acres) projected to require remediation to meet the near-shore PRG we have derived, a 100 ug/kg RAL would require active remediation of approximately 240 acres. Moreover, according to LWG, adopting this conservative RAL would still not result in the channel-wide PRG being met within multiple one-mile river reaches.

In summary, while using the Study Area-wide near-shore sediment data do not distinguish between east and west bank sediment concentrations, or incorporate the smaller spatial scale of SMB habitat (i.e., approximately 1 mile), it does result in a Study Area-wide model that more accurately characterizes the relationship between SMB (and other species) sediment exposure and tissue concentrations than the approach taken by LWG. Moreover, the near-shore PRG derived using the amended model would require remediation of over an order of magnitude less area than that predicted using the existing channel-wide PRG. This finding illustrates the high degree of uncertainty and conservatism incorporated into LWG's Bioaccumulation Model.

Summary

Multiple concerns regarding the LWG Bioaccumulation Model are documented in these comments. These call into question the ability of the model, as currently constmcted and parameterized, to achieve LWG's stated objective of developing predictive relationships between PCB concentrations in sediment, water, and tissue, both now and under a variety of prospective remedial action scenarios. Furthermore, the evidence indicates that the model is substantially low-biased in its prediction of PRGs.

The uncertainty and conservatism within LWG's methodology is underscored by the findings of a model re-evaluation performed by FMC to analyze target species' exposure on a near-shore, rather than channel-wide, basis. While it still does not comprise the optimum approach to modeling exposure, FMC's amended approach is better suited to PRG development than that used by the LWG because it more accurately characterizes actual exposure of the target species of primary concem (i.e., SMB) based on the findings of the same study used by EPA to support

[2] Note that implementation of a Study Area-wide RAL, rather than RM-specific RALs, has the potential to result in over-remediation of many reaches of the river. For example, implementation of a Study Area-wide RAL of 200 ug/kg would result in over-remediation of all areas of the river, except Swan Island Lagoon; i.e., the near-shore PRG for SMB can be attained within all other areas of the river with RALs greater than 200 ug/kg (see Table 2).

the one mile basis for evaluating achievement of the PRG (EPA, 2012). Furthermore, overall model performance, as measured by SPAFs for other target species (Table 1) and for individual SMB samples (Attachment B), is equivalent (if not better) using the amended exposure characterization compared to the LWG calibrated model.

Modifying the low-biased PRG predictions of the LWG model significantly affects the scope of the PCB sediment remediation that may be required. By comparison to LWG's PRG, the near-shore PRG for fisher consumption of SMB (i.e., the risk driving pathway), derived via application of the amended exposure assessment, would require comparatively little active remediation to achieve. In fact, it is anticipated that adoption of the high-end Total PCB RAL currently being evaluated in the draft FS (1,000 ug/kg) would meet this near-shore PRG on a Study Area-wide basis, as well as within most one-mile reaches of the river. Furthermore, as shown in Figure 8, the LWG anticipates that the same high-end RAL would achieve even their highly conservative PRG for this exposure scenario within 10 years of remedy completion.

In light of these observations, LWG's PRG is based on a flawed draft Bioaccumulation Model and should not be used as the technical basis for evaluating PCB remedial altematives in the draft FS. If the LWG draft model nevertheless continues to be used without the complete reassessment that FMC believes is needed, the near-shore PRG derived in this review should be considered more technically valid than LWG's current PRG.

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Table 1
Comparison Between Species Predictive Accuracy Factors (SPAFs) for LWG Calibrated Bioaccumulation Model and FMC Amended Model *

	Modeled Species						
	Clams	Crayfish	Sculpin	Sucker	Carp	Small Mouth Bass	Pikeminnow
Study Area-Wide Mean Total PCB Empirical Tissue Concentration (ug/kg wet weight)	230	68	690	880	2700	1100	870
FMC Amended Model - Predicted total PCB Tissue Concentrations (ug/kg wet weight)	61	85	313	595	734	1101	867
FMC Amended Model SPAF	3.8	***1.3***	2.2	1.5	3.7	***1.0***	***1.0***
LWG Calibrated Model - Predicted total PCB Tissue Concentrations (ug/kg wet weight)	51.6	91.4	341.0	609.3	737.0	1386.0	1052.3
LWG Calibrated Model SPAF	4.5	***1.3***	2.0	***1.4***	3.7	***1.3***	***1.2***

* Bold-italicized indicates model Is overpredicting.

Table 2
Influence of Potential Remedial Action Levels (RALs) on Near Shore Total PCB SWACs

A) Near-Shore PRG-SWAC Evaluation

Location	No Action	Remedial Action Level (RAL) (ug/kg)			
		1000 (23 acre remedy)	500 (47 acre remedy)	200 (110 acre remedy)	100 (240 acre remedy)
Study Area	134.3	59.4	47.4	33.4	23.0
RM 2 to <3	88.8	30.0	23.9	19.3	16.4
RM 3 to <4	64.6	29.7	29.7	21.3	18.4
RM 4 to <5	78.5	47.0	43.8	35.9	29.5
RM 5 to <6	42.7	42.7	42.7	29.6	22.4
RM 6 to <7	91.8	48.0	48.0	38.6	24.3
RM 7 to <8	78.2	56.5	35.9	32.2	23.0
RM 8 to <9	161.6	53.2	46.9	41.0	29.7
Swan Island	462.0	174.3	119.9	54.0	26.4
RM 9 to <10	139.5	77.2	58.7	46.6	25.9
RM 10 to <11	42.2	42.2	42.2	32.6	28.2
RM 11 to 11.8	160.9	38.1	33.0	25.7	18.9

Near-shore Total PCB SWAC less than near shore 1-mile PRG (61.3 ug/kg).

B) Channel-Wide PRG-SWAC Evaluation

Location	No Action	Remedial Action Level (RAL) (ug/kg)			
		1000 (23 acre remedy)	500 (47 acre remedy)	200 (110 acre remedy)	100 (240 acre remedy)
Study Area	85	50	42	34	25.5
RM 2 to <3	51	31	29	25	22
RM 3 to <4	48	30.5	27.5	25.5	19.5
RM 4 to <5	42.5	42.5	31	28	26
RM 5 to <6	23.8	23.8	23.8	23.8	20
RM 6 to <7	76	55	55	51	29.5
RM 7 to <8	42	42	42	35	32
RM 8 to <9	98	41	41	36	29.5
Swan Island	670	230	145	60	15
RM 9 to <10	62	62	51	35	29
RM 10 to <11	50.5	50.5	50.5	50.5	35
RM 11 to 11.8	90.5	52.5	29	26	22

Channel-wide Total PCB SWAC less than river-wide 1-mile PRG (29.5 ug/kg).

Figure 1
LWG Mechanistic Bioaccumulation Model Calibration Process *

Non-Chemical-Specific Calibration

Model was first run probabilistically 50,000 times with total PCBs (K_{ow} = 7.40)

All parameters were allowed to vary with the exception of the sediment concentration, which was held constant.[1]

Model output was sorted based on the SPAF for smallmouth bass, and the top 25 model runs were selected while also optimizing the SPAFs for other species.

The model was then run deterministically with these 25 parameter sets to evaluate the model's ability to predict on a smaller spatial scale for individual smallmouth bass composite samples. The top 4 parameter sets were selected.

The model was then run deterministically for these four parameter sets for the five additional calibration chemicals (PCB 17, PCB 118, PCB 167, 4,4'-DDE, and total DDTs)[2], both on a site-wide basis and for smallmouth bass on a smaller spatial scale.

The best parameter set was selected. As with total PCBs, the model performance improved with the use of the calibrated parameter values.

Chemical-Specific Calibration

The model was parameterized with all of the non-chemical-specific calibrated values.

Chemical-specific parameter values for chemical concentration in sediment, chemical concentration in water, K_{ow}, and metabolic rate constant were entered into the model.

Distributions were defined for the chemical-specific K_{ow} and water concentration and the model was run probabilistically 1,000 times.

The model output was sorted based on the SPAF for smallmouth bass, while also optimizing the SPAFs for other species. The best model run was used to select the calibrated K_{ow} and water concentration.

For chemicals known to be metabolized, the calibrated K_{ow} and water concentration were entered into the model, and distributions were defined for the metabolic rate constants before again probabilistically running the model 1,000 times.

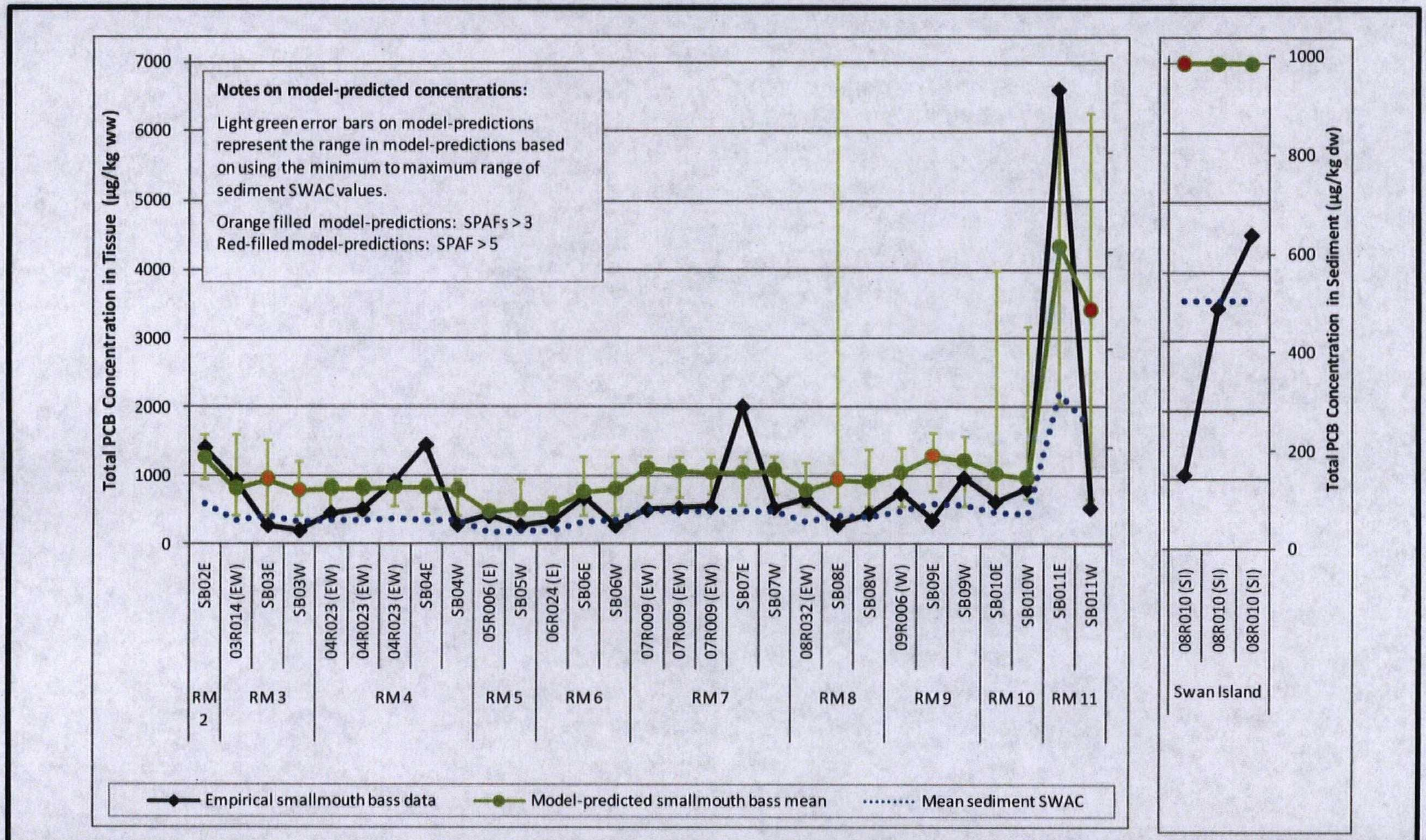
Again, the model output was sorted based on the SPAF for smallmouth bass, while also optimizing the SPAFs for other species. The best model run was used to select the calibrated metabolic rate constants.

[1] When PRGs were calculated, the actual sediment concentration was not used, and thus the calibration of this parameter was not necessary.

[2] Uncalibrated chemical-specific parameters (chemical concentration In water, chemical concentration in sediment, and K_{ow}) were used for this assessment.

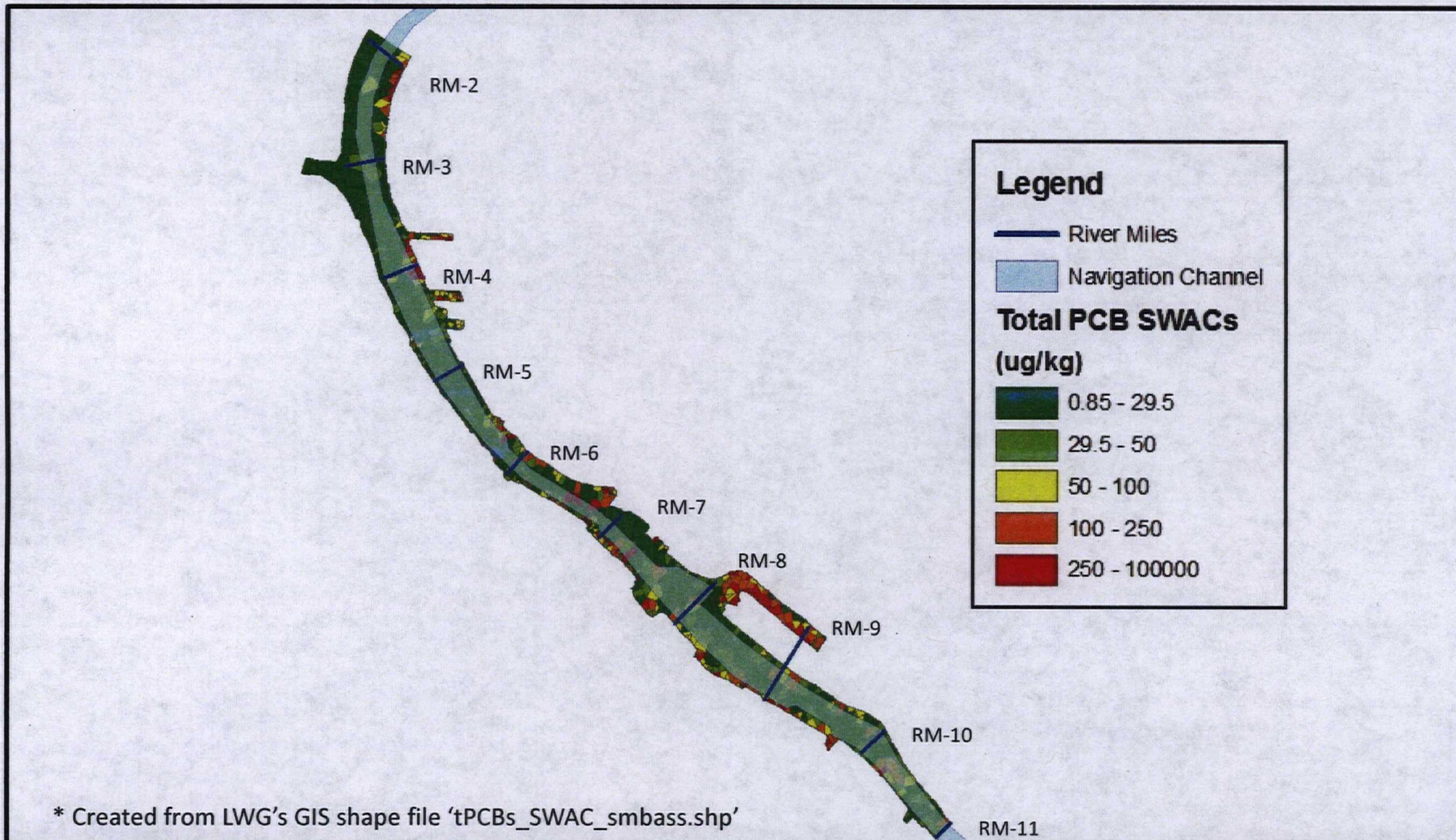
* Figure 5-1 of the LWG Bioaccumulation Modeling Report (Windward, 2009a).

Figure 2
Empirical and LWG Model-Predicted Smallmouth Bass Tissue Concentrations for Total PCBs *



* Figure 5-18 of the LWG Bioaccumulation Modeling Report (Windward, 2009a).

Figure 3
Total PCB Near Shore and Navigation Channel Sediment SWACs for the Portland Harbor Study Area *



* Created from LWG's GIS shape file 'tPCBs_SWAC_smbass.shp'

Figure 4
Study Area-Wide Calibrated Model Performance for Total PCBs *

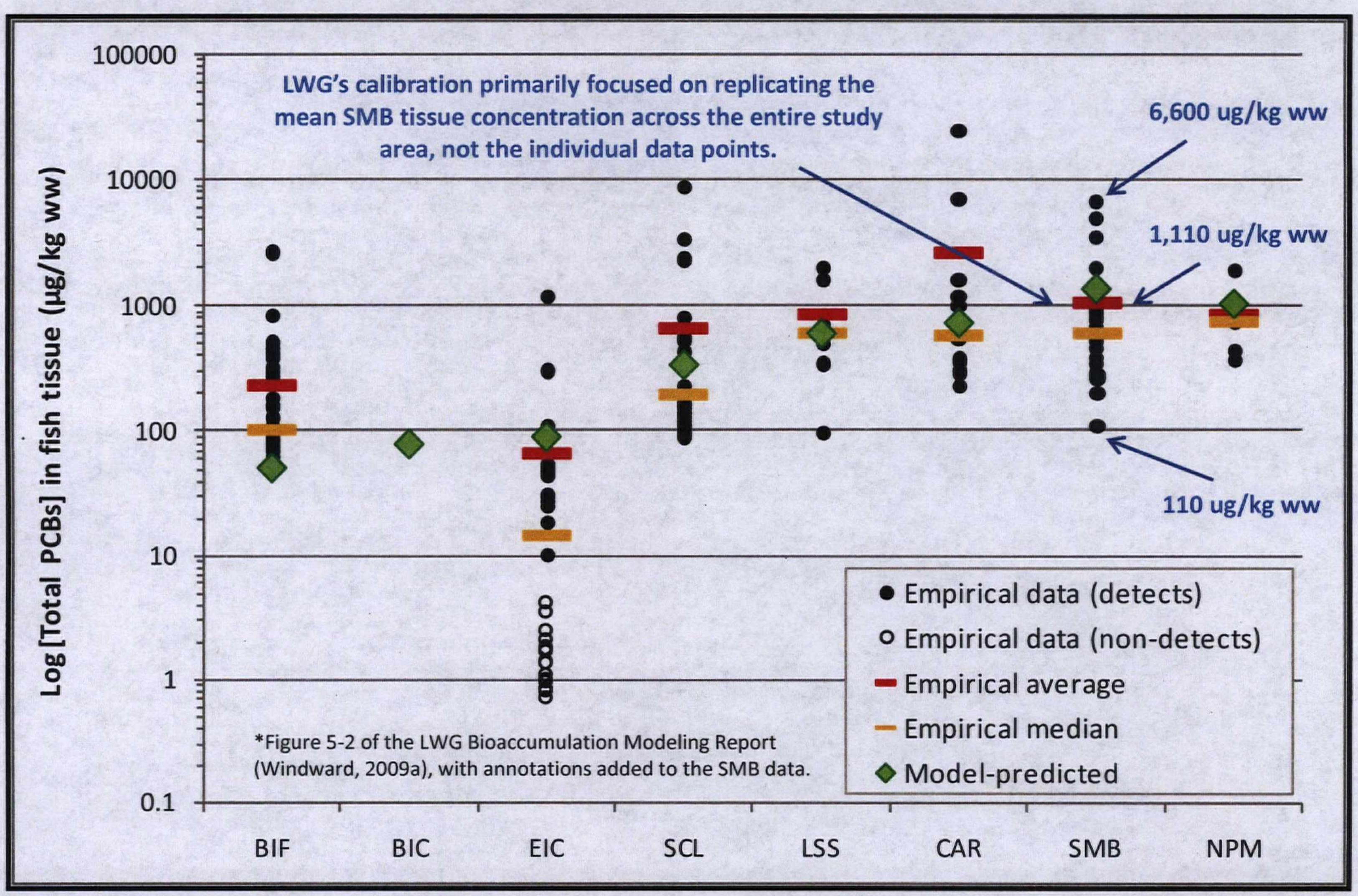


Figure 5
Comparison of Near Shore and Channel-Wide Sediment SWACs to SMB Tissue Concentration Trends

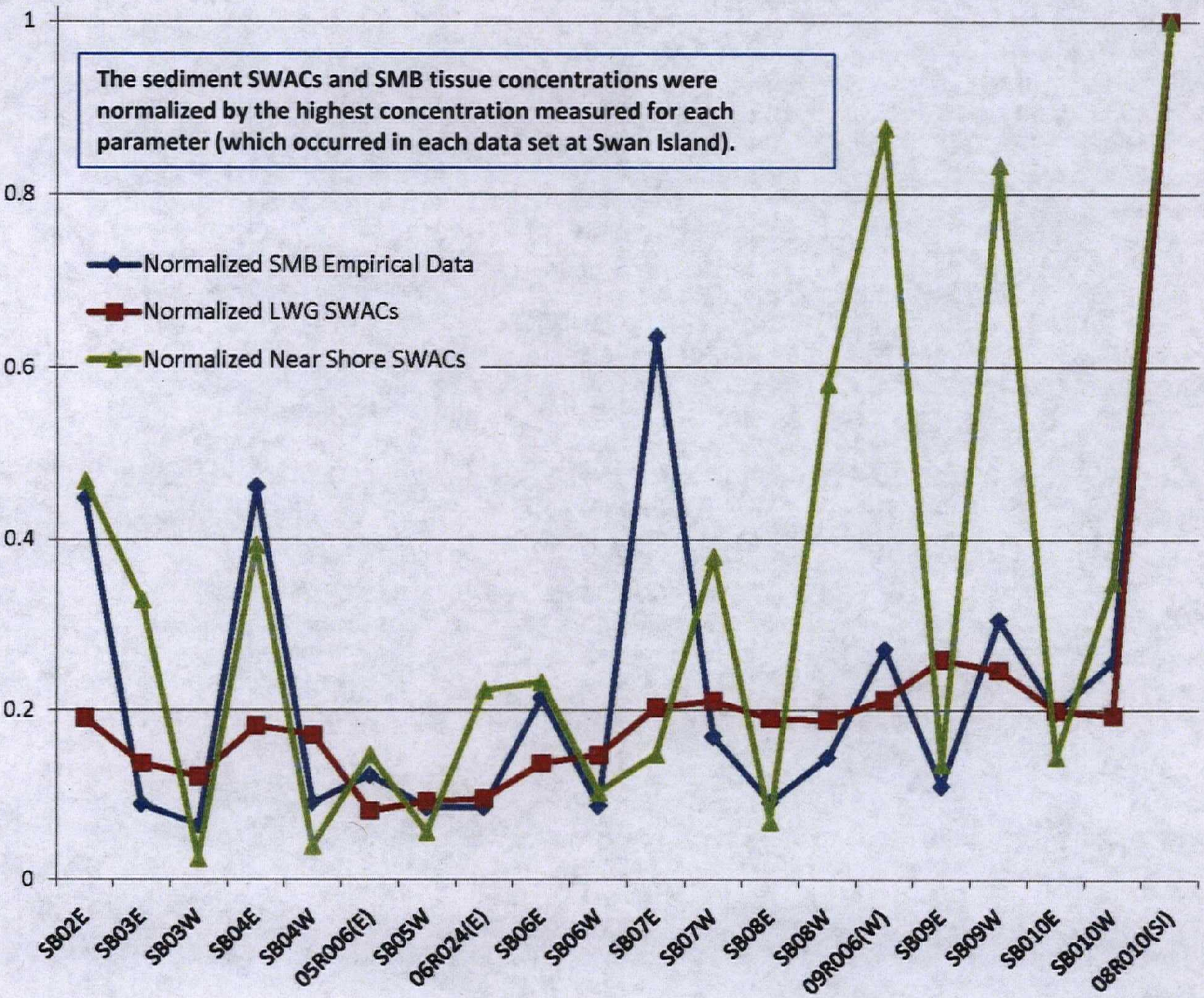
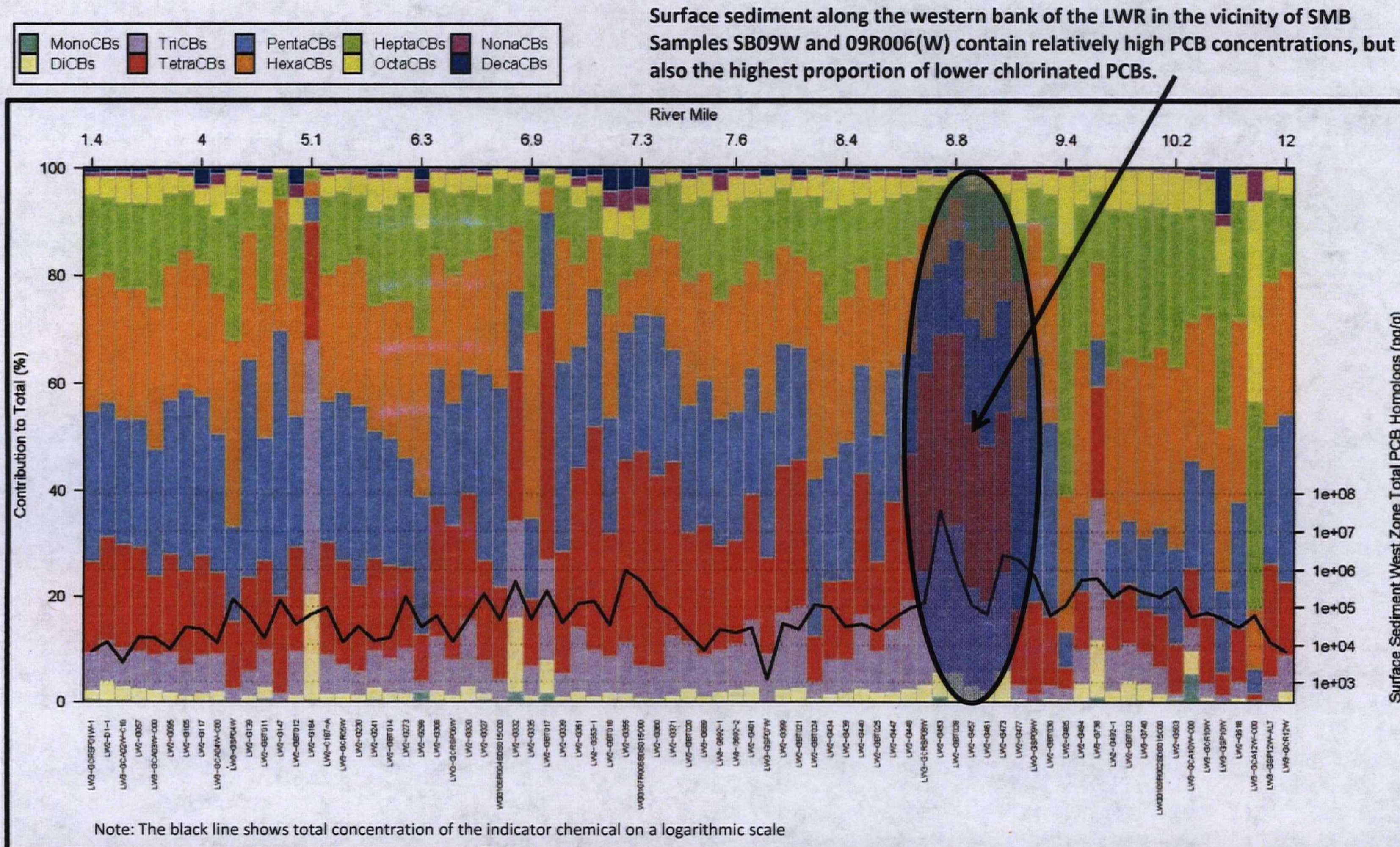
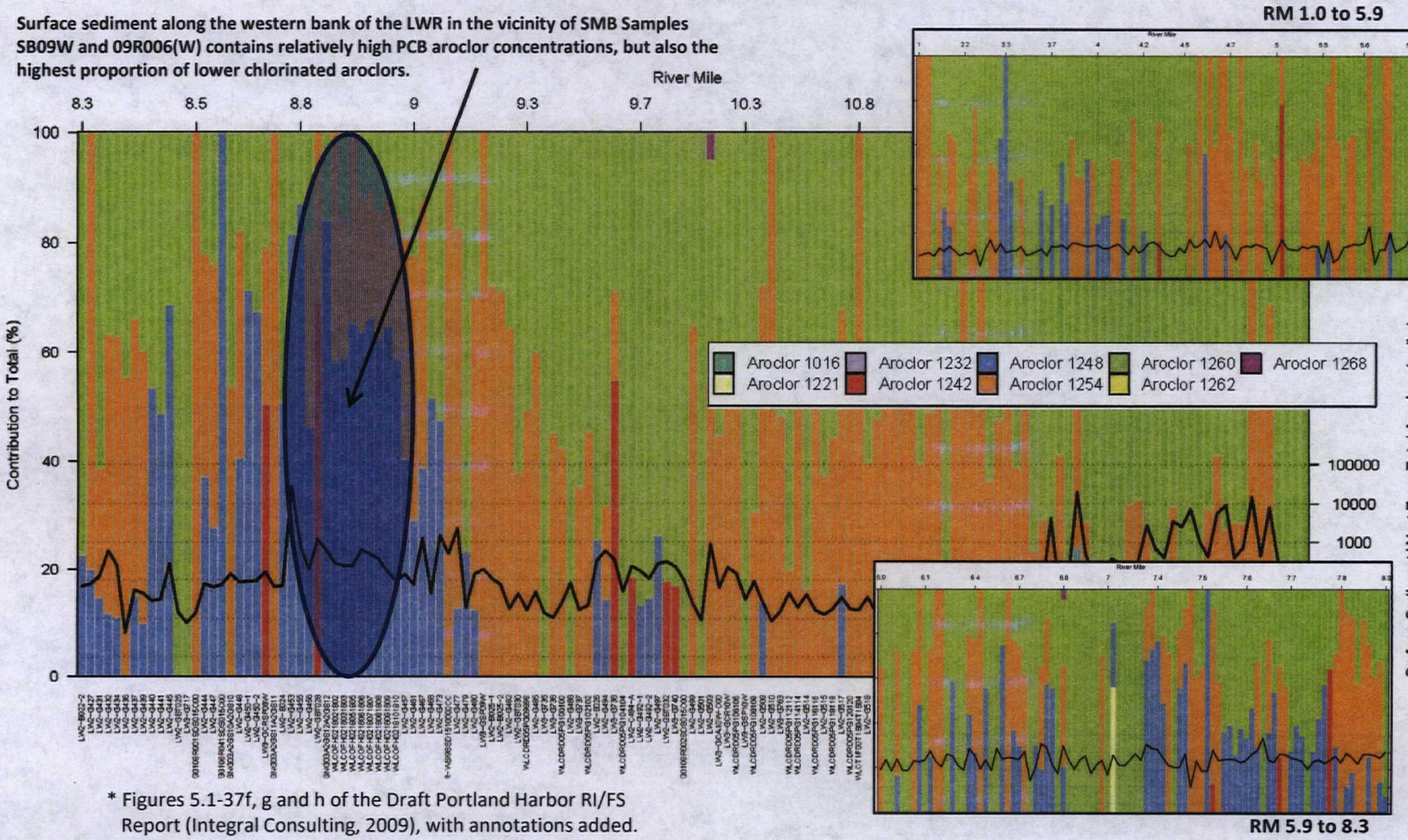


Figure 6
Stacked Bar Chart Showing PCB Homolog Patterns in Surface Sediment
(RM 1.4 to 12.0, West Zone) *



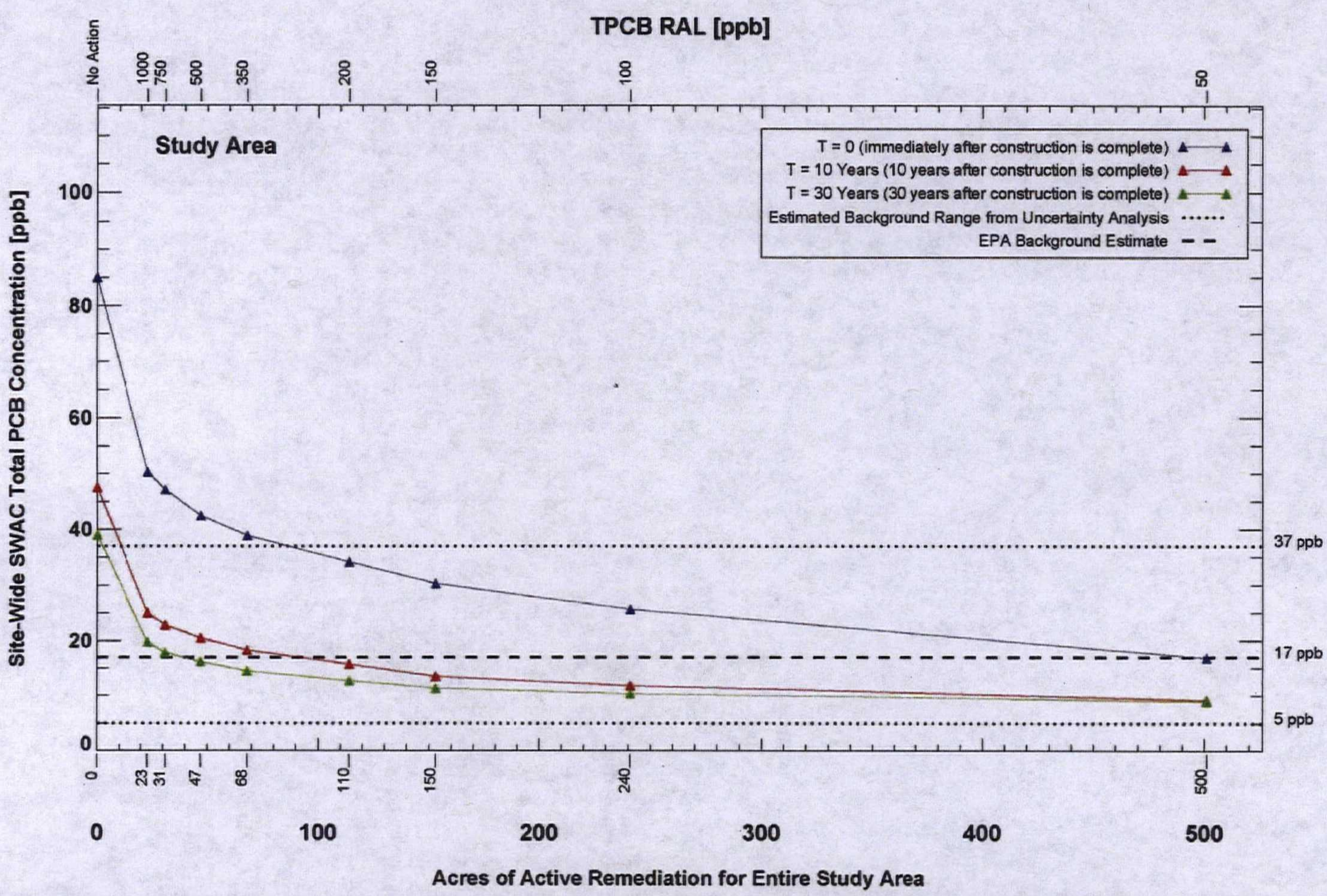
* Figure 5.1-35c of the Draft Portland Harbor RI/FS Report (Integral Consulting, 2009), with annotations added.

Figure 7
Stacked Bar Chart Showing Aroclor Patterns in Surface Sediment (RM 8.3 to 14.0, West Zone) *



* Figures 5.1-37f, g and h of the Draft Portland Harbor RI/FS Report (Integral Consulting, 2009), with annotations added.

Figure 8
LWG Comparison of Total PCBs Site-wide SWAC to Potential RALs



ATTACHMENT A: Model Discrepancies

In addition to the issues surrounding the model calibration and calibrated model performance, several discrepancies between the algorithms and parameter values presented in the LWG report for the calibrated model versus those documented in the Portland Harbor RI, or recommended in the Amot and Gobas (2004) FWM, were noted. Internal discrepancies between reported methods were also noted in different sections of the bioaccumulation report. Examples of such discrepancies include:

1. The report does not describe how the organic carbon partition coefficient (Koc), one of the more sensitive required input parameters, was characterized in the calibrated model. However, LWG's reported SPAFs were able to be replicated when the following equation was used to characterize Koc (Seth et al., 1999):

   $$KOC = 0.35 \times KOW \qquad \textbf{\textit{Equation 1}}$$

   Where:

   KOC = Organic carbon partition coefficient (unitless), and,
   KOW = Octanol-water partition coefficient (unitless).

   The above equation is consistent with the approach recommended for characterizing Koc in Amot and Gobas (2004) and within EPA's KABAM model. However, it differs from the approach used for other Portland Harbor site studies, as documented in Appendix E (Loading, Fate, and Transport Supporting Information and Calculations) of the draft RI report which relied on DiToro's approach (1991):

   $$Log10KOC = 0.00028 + Log10KOW \times 0.983 \qquad \textbf{\textit{Equation}}\ 2$$

   Appendix E of the RI report justifies use of the above relationship by stating "EPA found that the DiToro equation was subject to less uncertainty than other equations (EPA 2003)". Use of different methods to derive a chemical-specific parameter in RI/FS studies is inconsistent and not technically justifiable. Using DiToro's equation to characterize Koc results in nearly a <u>17% lower</u> predicted total PCB SMB tissue concentration in the calibrated model for current conditions.

2. To characterize the gill ventilation rate of zooplankton, invertebrate and fish species, LWG calculates the dissolved oxygen surface water concentration (COX) assuming the water column is 90% saturated:

$$COX = (-0.24 \times T + 14.04) \times S \qquad \textbf{\textit{Equation 3}}$$

Where:

COX = Dissolved oxygen concentration (mg O_2/L),
T = Water temperature (°C), and
S = Degree of oxygen saturation in water column (LWG = 90%).

No justification for the assumed degree of oxygen saturation was found in any of the LWG model documentation. Amot and Gobas (2004) identifiy a range of 85% to 95% dissolved oxygen saturation at several study locations in North America. Substituting 85% oxygen saturation into the above equation results in nearly a <u>7% lower</u> predicted Total PCB SMB tissue concentration in the calibrated model for current conditions.

3. The LWG model's estimation of the chemical uptake efficiency across the gills (E_w) uses a different equation than cited by Amot and Gobas (2004).

<u>Amot and Gobas (2004)</u>

Equation 4

$$E_w = 1/\left(1.85 + \left(\frac{155}{K_{ow}}\right)\right)$$

<u>LWG (2009)</u>

Equation 5

$$E_w = 1/\left(1.89 + \left(\frac{155}{K_{ow}}\right)\right)$$

LWG does not justify the above discrepancy (a constant of 1.89 versus 1.85), but simply states that the model is relatively insensitive to parameterization errors in E_W (Appendix E, pg. 8). However, altering the characterization of Ew in the calibrated LWG model to conform with Amot and Gobas' recommended value (1.85) results in approximately a <u>3% lower</u> prediction of SMB tissue concentration in the calibrated model for current conditions.

4. The LWG model's estimation of the growth rate constant (K_G) also uses a different equation than cited by Amot and Gobas (2004).

Arnot and Gobas (2004)

$$K_G = 0.0005 \times WB^{-0.2} \qquad \textbf{\textit{Equation 6}}$$

Where:

KG = Growth rate constant (1/days), and
WB = Organism body weight (kg).

LWG (2009)

$$K_G = 0.000502 \times WB^{-0.2} \qquad \textbf{\textit{Equation 7}}$$

LWG acknowledges that the Amot and Gobas (2004) equation is the recommended approximation for growth rate in the absence of empirical data for water temperatures around 10° C (pages 9 and 10 of Appendix E). No justification is provided for why the LWG amended version of the equation was subsequently incorporated into the calibrated model. Amending the characterization of K_G in the calibrated LWG model to conform with Amot and Gobas' recommended equation results in less than a 1% change (increase) in predicted SMB total PCB tissue concentration under current conditions.

5. In calculating chemical concentration in filter feeder tissue, the rate at which chemicals are absorbed from the diet via the gastrointestinal tract (K_D) is characterized as follows (pg. 29 Appendix E):

$$(GV/WB) \times CPW \times ED \times Food4D \qquad \textbf{\textit{Equation 8}}$$

Where:

GV = Gill ventilation rate (L/day),
WB = Organism body weight (kg),
CPW = Concentration of suspended solids (kg/L),
ED = Intestinal tract chemical transfer efficiency (unitless),
Food4D= Intermediate calculation term (unitless).

However, this characterization is not equivalent to the dietary uptake rate constant (KD) for filter feeders as cited by Amot and Gobas (2004). The actual term should be:

$$KD = (GV/WB) \times CPW \times ED \times SCV \times Food4D \qquad \textbf{\textit{Equation 9}}$$

Because LWG assumes that the scavenging efficient (SCV) of filter feeders is one, this discrepancy has no effect on the model output; however, it does prevent the model from being used to consider differing scavenging efficiencies.

6. The calibrated values used to characterize the diet of common carp, as provided in Table 5-11, consists of the following: 4% sediment solids, 33% phytoplankton/algae, 14% benthic invertebrates (filter feeders), and 48% benthic invertebrates (consumers). These calibrated prey item diet percentages sum to 99% and, therefore, do not characterize the entire diet of common carp. It is ımclear how the calibration process resulted in a total diet of less than 100%.

7. Page 11 of Appendix E indicates that the following equation was used to characterize the organism-water partition coefficient (KPW) for phytoplankton:

Equation 10

$$KPW2 = (VLB2 \times KOW) + (VNB2 \times (GAMMA \times 10) \times KOW) + VWB2$$

Where:

KPW2 = Organism-water partifion coefficient (unitless),
VLB2 = Lipid fraction of organism (unitless
VNB2 = Non-lipid organic matter fraction of organism (unitless),
VWB2 = Water fraction of organism (unitless)
KOW = Octanol-water partition coefficient (unitless), and
GAMMA=Non-lipid organic carbon (NLOC) proportionality constant (unitless).

By contrast, pg 27 of Appendix E indicates that a different equation was used to characterize KPW:

Equation 11

$$KPW2 = (VLB2 \times KOW) + (VNB2 \times GAMMA \times KOW) + VWB2$$

The latter equation is consistent with Amot and Gobas (2004) and was presumably incorporated into the calibrated Bioaccumulation Model; however, given that an electronic copy of the model was not made available for review, this assumption could not be confirmed.

8. Appendix E, page 9 identifies the following equation for estimating the partition coefficient between the gut contents of an organism and its tissue (K_{GB}):

Equation 12

$$KGB = (\frac{(\mathrm{VLG} \times \mathrm{KOW} + \mathrm{VNG} \times \mathrm{BETA} \times \mathrm{KOW} + \mathrm{VWG})}{\mathrm{VLB} \times \mathrm{KOW} + \mathrm{VNB} \times \mathrm{BETA} \times \mathrm{KOW} + \mathrm{VWB})}$$

Where:

KGB	=	Gut-organism partition coefficient (unitless),
VLB	=	Lipid fraction in organism gut (unitless),
VNG	=	NLOM fraction in organism gut (unitless),
VWG	=	Water fraction in organism gut (unitless),
VLB	=	Lipid fraction of organism (unitless),
VNB	=	Non-lipid organic matter fraction of organism (unitless),
VWB	=	Water fraction of organism (unitless)
KOW	=	Octanol-water partition coefficient (kg/L), and
BETA	=	NLOM proportionality constant (unitless).

Information needed to characterize or calculate each of the terms within the above equation is provided in the report.

However, the model code presented on pages 28 through 37 of Appendix E uses a different equation for estimating KGB for each species of concem:

Equation 13

$$KGB = (\frac{(\mathrm{VLG} \times \mathrm{Zlipid} + \mathrm{VNG} \times \mathrm{BETA} \times \mathrm{Zlipid} + \mathrm{VWG} \times \mathrm{Zwater})}{\mathrm{VLB} \times \mathrm{Zlipid} + \mathrm{VNB} \times \mathrm{BETA} \times \mathrm{Zlipid} + \mathrm{VWB} \times \mathrm{Zwater})}$$

Where:

Zlipid	=	Lipid fugacity (mol m^{-3}/Pa), and
Zwater	=	Water fugacity (mol m^{-3}/Pa).

As documented in Appendix E equations 3 and 4, the Zlipid and Zwater terms are dependent upon the temperature-compensated Henry's Law constant (HT), the value of which is not provided within the model documentation, and the octanol-water partition coefficient (K_{OW}):

Equation 14

$$Zwater = \frac{1}{\mathrm{HT}}$$

Where:

HT = Temperature-compensated Henry's Law constant (Pa m^{-3}/mol).

$$Zlipd = Zwater \times KOW$$

Equation 15

Review of equations 12 and 13 reveals that they both produce the same value for KGB, regardless of the characterization of HT, Zlipid and Zwater, but this result is not intuitively obvious. Consequently, the discrepancy in documented equations is confusing to the review process.

References

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Windward. 2009. Portland Harbor RI/FS – Draft Bioaccumulation Modeling Report. July 21, 2009.

ATTACHMENT B: Method and Findings of Bioaccumulation Model Re-Evaluation

This attachment describes in detail the steps taken to re-evaluate LWG's draft Bioaccumulation Model using near-shore Total PCB concentrations. While numerous sources of uncertainty in LWG's model are identified in the main body of this report, this re-evaluation was undertaken due to the fact that it mischaracterizes exposure for the target species of greatest concern, small mouth bass (SMB). Specifically, despite the fact that SMB primarily feed near the shoreline and within a limited reach (approximately 1 mile) (Pribyl et al., 2005), the LWG model assumes exposure occurs uniformly across both the entire length of the Study Area (approximately 10 miles) and the entire width of the river (i.e., including the navigation channel). LWG technical staff acknowledged this mischaracterization during an October 2010 meeting to discuss FMC's initial comment document. However, LWG did not believe that it would significantly alter either the model findings or the significance of preliminary remediation goals (PRGs) developed using the model, although they acknowledged that no study had been performed to verify this conclusion.

The analysis documented herein attempts to evaluate the significance of LWG's exposure mischaracterization. However, a completely different modeling approach, requiring resources beyond the scope of this review, would be needed to most appropriately characterize exposure over the 1 river mile home range of SMB. Consequently, this re-evaluation instead focused upon correcting the other facet of LWG's exposure mischaracterization (i.e., near-shore versus channel-wide[3] SMB exposure), and using the amended model to develop and analyze the significance of an alternate near-shore PRG.

Amendment of the LWG Model

LWG's draft Bioaccumulation Model report did not provide an electronic copy of the calibrated model, or the raw data used to characterize multiple input parameters. FMC previously developed an EXCEL file ("Kabam Model - Recreate LWG Calibrated Model (07-30-2010).xlsx") to recreate the Total PCB findings of the LWG Bioaccumulation Model, which is provided in electronic format with this report (see CD). However, in order to re-evaluate the model on a near-shore exposure basis, FMC also required the interpolated Total PCB data used by LWG to characterize the Study Area-wide sediment spatially weighted average concentration (SWAC) in the calibrated model[4]. In response

[3] Throughout this document, the term "channel-wide" refers to the width of the river on a bank-to-bank basis.

[4] FMC's July 2010 comments relied upon interpolated SWAC data downloaded from LWG's public portal (https://portal.webpe.com/portal/page/portal/LWG/LWG_PUBLIC). However, these datasets did not cover the entire Study Area as they were missing information for RM 11 to RM 11.8.

to requests for this information, LWG provided FMC with the following materials (Marsh, 2011):

1. An EXCEL workbook "PCB_SWACs_BERA_or_wFS_20110510.xlsx" (see attached CD) which included, along with other supporting information, the following Total PCB data:

    a. Total PCB concentrations from a hybrid of aroclor and congener data collected at unique baseline ecological risk assessment (BERA) sample locations, and select feasibility study (FS) sample locations in river mile (RM) 11E and at T4 which meet the BERA criteria (QA2Cat1). These BERA + FS data reportedly originated from the LWG_SCRA_Baseline_PostBERA.accdb sediment dataset (Marsh, 2011).

    b. Total PCB concentrations from aroclor data collected at unique BERA sample locations, and select FS sample locations in river mile (RM) 11E and at T4 which meet the BERA criteria (QA2Cat1). These BERA + FS data reportedly originated from the LWG_SCRA_Baseline_PostBERA.accdb sediment dataset (Marsh, 2011).

    c. Interpolated Total PCB concentrations, as represented by Thiessen polygons, derived from the hybrid BERA + FS dataset. The RM and location (i.e., east bank, west bank, navigation channel, Swan Island Lagoon) of each Thiessen in this interpolated dataset (and all other interpolated datasets identified in 1d, 1e, 1f and 1g) was identified.

    d. Interpolated Total PCB concentrations for the Study Area, as represented by Thiessen polygons, derived from the aroclor BERA + FS dataset.

    e. Interpolated Total PCB concentrations for the Study Area, as represented by Thiessen polygons, derived from the hybrid BERA dataset (i.e., not supplemented with FS data).

    f. Interpolated Total PCB concentrations for the Study Area, as represented by Thiessen polygons, derived from the aroclor BERA dataset (i.e., not supplemented with FS data).

    g. Interpolated Total PCB concentrations for the Study Area, as represented by Thiessen polygons, derived from a hybrid of congener and aroclor data within the 2008 Site Characterization and Risk Assessment (SCRA) database.

    h. A summary ofi both Study Area and RM-specific Total PCB SWACs, based on natural neighbor interpolation of the various combinations of aroclor, hybrid, BERA and BERA + FS data.

2. An ArcGIS layer package, fitled "Current PCB Thiessens.lpk" (see CD), which contains GIS coverage depicting the interpolated Thiessen polygon Total PCB

concentrations derived from the datasets described in bullets 1c, 1d, 1e and 1f above.

3. An ArcGIS layer package, titled "Hybrid PCBs – 2009 bioaccumulafion model.lpk" (see CD), which contains GIS coverage depicting interpolated Thiessen polygon and natural neighbor Total PCB concentrations associated with the 2008 SCRA database.

The 2008 SCRA database was reportedly used to characterize the channel-wide Total PCB sediment SWAC (92.6 ug/kg) for the Study Area within LWG's Bioaccumulafion Model. Thus, the interpolated Thiessen polygons developed by LWG from the 2008 SCRA database were used to derive an equivalent near-shore sediment SWAC for the Study Area (i.e., the Total PCB SWAC for sediments on the east and west banks of the LWR and within Swan Island Lagoon). Calculation of the near-shore SWAC is documented in green highlighted columns T and U in the "Near-Shore SWAC Calculafion (02-20-2012).xlsx" EXCEL file (see CD)[5].

The resulting near-shore Total PCB sediment SWAC, 144.3 ug/kg, was entered in place of LWG's charmel-wide SWAC (92.6 ug/kg) to characterize the sediment exposure concentration in the EXCEL file developed by FMC to recreate the results of LWG's calibrated bioaccumulation model for Total PCBs. The most sensitive model parameter, the Total PCB octanol-water partition coefficient (Log Kow), was then adjusted to a value (5.91) that accurately predicted the mean tissue concentration detected in SMB samples collected throughout the Study Area. While this Log Kow is at the low-end of the plausible range for Total PCBs, re-calibration of all parameters within the amended model would likely result in refinement to this value. FMC did not perform a re-calibration because this evaluation is simply intended to illustrate the potential significance of LWG's exposure mischaracterizafion. Moreover, as a third-party to the RI/FS process, with other fundamental concems regarding the validity of LWG's overall modeling approach, expenditure of the significant resources necessary to perform such an exercise was deemed beyond the scope of this review. The amended model is provided in the attached "Kabam Model – Amended Near-Shore Model (02-20-2012).xlsx file (see CD).

As shown in Table B-1, amending the LWG model to more accurately characterize near-shore SMB exposure results in Species Predictive Accuracy Factors (SPAFs) for the other modeled species that are equivalent to those produced by LWG's calibrated model

[5] A different interpolation of the 2008 SCRA dataset (natural neighbors versus Thiessen polygons) was used to derive the channel-wide SWAC used in LWG's model; however, the near-shore SWAC derived from the Thiessens (144.3 ug/kg) is essentially the same as that derived by LWG from natural neighbor interpolation of the more recent hybrid BERA (146.4 ug/kg) and hybrid BERA + FS (142.6 ug/kg) datasets. Thus, use of the Thiessen-based SWAC in this analysis is considered reasonable.

(i.e., the amended model is equally capable of predicting the average fissue concentrations detected in field samples collected across the Study Area). In fact, the average SPAF for species other than SMB in the FMC amended model (2.23) is over 5% better (i.e., lower) than the average SPAF derived in LWG's model. This finding is remarkable given that LWG performed over 50,000 model iterations to calibrate its model.

Finally, FMC compared the predictive performance of the two models over the smaller spatial scale applicable to SMB (i.e., 1 river mile). This analysis was performed by comparing predicted tissue concentrations from the LWG and amended models to the measured concentrations in individual SMB composite samples collected from the near-shore of specific river miles during the RI. Whole body SMB tissue concentrations, as calculated for use in the BERA, were obtained from LWG's SCRA. These data are shown in column E of the 'Summary' worksheet in the attached "LWG Versus Amended Model Small Scale Performance (02-20-2012).xlsx" EXCEL file (see CD). LWG's characterization of the channel-wide average sediment SWAC associated with each SMB composite sample, as documented in Table 5a of Appendix B to the draft LWG Bioaccumulation Report (Windward, 2009), was then entered into FMC's recreation of the LWG model to produce a tissue concentration estimate for each sample. The LWG sediment SWACs and tissue concentration estimates are shown in columns F and G of the 'Summary' worksheet in the above-referenced EXCEL file.

The near-shore sediment SWAC for each SMB composite sample was calculated by inifially using Map 2.2-10 (a-d) of the Draft RI report to identify the tenth of a river mile in which each fish comprising a composite SMB sample was caught. Interpolated Thiessen polygon concentrations for sediments located 0.5 miles up- and down-stream of, and on the same bank as, the fish sample location were then used to calculate a corresponding sediment SWAC. The sediment SWACs calculated for each fish comprising the composite sample were then averaged to generate the mean sediment SWAC to which fish in the composite were assumed to have been exposed. The mean sediment SWACs were then entered into the amended model to produce SMB tissue concentration predictions for each empirical data point. These sediment SWACs and tissue concentration estimates are shown in columns I and J of the 'Summary' worksheet in the above-referenced EXCEL file. The sediment SWAC calculations for each SMB sample are also presented in this EXCEL file.

Table B-2 and Figure B-1 summarize the results of this analysis. As shown in the table, the average SPAF associated with the LWG model predictions for each SMB sample (2.13) is over 8% higher (i.e., less accurate) than the average SPAF predicted using the amended model (1.96). Moreover, Figure B-1 shows that for the majority of SMB samples the amended model produces either more accurate predictions (10 of 22) or equivalently accurate predictions (6 of 22) to those of the LWG model. Furthermore, of the 6 instances in which the LWG model produces better concentration estimates than the amended model, the majority (4 of 6) do not accurately portray the empirical data.

However, most noteworthy is the fact that the amended model is considerably more accurate in predicting the empirical data for samples in which relatively low tissue concentrations were detected (<= 625 ug/kg ww). In fact the average SPAF for these 13 samples using the amended model (1.87) is nearly 30% lower than the average SPAF using the LWG model (2.60). This finding is important because the PRG for human consumption of SMB is established based on a similarly low target tissue concentration (470 ug/kg ww).

In summary, the amended near-shore model better simulates the Total PCB concentration fluctuations observed in SMB tissue samples collected throughout the Study Area. In contrast, the LWG model consistently overestimates tissue concentrations for SMB samples in which low PCB levels were measured, and overestimates tissue concentrations in SMB samples in which high PCB levels were detected. This is a critical flaw since, as discussed later, the risk-based target tissue concentration for SMB is at the low-end of the range measured in the collected samples.

Near-Shore Preliminary Remediation Goal (PRG) Derivation

While it is FMC's position that modeling SMB exposure across the entire Study Area is not the optimum technical approach, the fact that the amended near-shore SWAC assessment more accurately characterizes SMB exposure, and that the amended model results in equivalent (if not better) predictive performance than LWG's calibrated model for other species, indicates that it is has a stronger technical basis for deriving a Total PCB PRG. Consequently, using the same scenario used by LWG to derive the channel-wide PRG of 29.5 ug/kg (i.e., the sediment concentration that would result in a SMB tissue concentration protective of non-Tribal adult fishers consuming 17.5 g/day at a 1×10^{-4} excess cancer risk), the amended model was used to determine a corresponding near-shore Total PCB sediment PRG.

To perform this task, the following changes were made to parameter values within the amended near-shore model:

1. Consistent with the approach taken by LWG, the Total PCB dissolved water concentration was characterized by the background concentration (0.105 ng/L), and
2. The near-shore sediment SWAC value was varied until the predicted Total PCB SMB tissue concentration was equal to the target tish tissue level for the receptor

of concem (470 ug//kg wet weight per Table 10.1-4 of the Portland Harbor RI/FS 2007 Comprehensive Round 2 Report [Integral, 2007]).

The above changes to the near-shore model are reflected in the attached "Kabam Model – Near-Shore PRG (02-20-2012).xlsx" EXCEL file (see CD). Based on the evaluation, a near-shore sediment Total PCB SWAC for the Study Area of 61.3 ug/kg was found to be consistent with the target fish tissue level. This concentration is therefore representative of a near-shore PRG protective of the receptor of concem (i.e., non-tribal adult fishers consuming SMB).

Comparison of FMC Near-Shore PRG to LWG Channel-wide PRG

While it is outside the scope of this assessment to quantitatively address all of the major uncertainties apparent within the LWG's Bioaccumulation Model, the amended model provides an altemate near-shore PRG that is based on a more realistic exposure characterization (although still Study Area-wide). The significance of this re-evaluation is best determined by assessing the relationship between the Remedial Action Levels (RALs) currently being considered in the Feasibility Study (FS) and PRG attainment. Thus, the analysis performed herein compares and contrasts the extent of the remediation necessary to achieve the near-shore PRG versus the LWG channel-wide PRG. Consistent with LWG's treatment of its channel-wide PRG, this analysis evaluates attainment of the near-shore Total PCB PRG on a 1 river mile SWAC basis, despite the fact that the PRG is derived on a Study Area-wide basis.

The interpolated Total PCB Thiessen polygons associated with the hybrid (i.e., congener and aroclor) BERA + FS sediment dataset were used to perform this evaluation. This dataset was used because it is considered more representative of current conditions within the Study Area than either the 2008 SCRA dataset used in the Bioaccumulafion Model, or any of the three other datasets provided by LWG.

Near-Shore PRG

The near-shore Thiessen polygon data were screened against potential RALs currently under evaluation in the draft FS (i.e., 1,000 750, 500, 350, 200, 150, 100 and 50 ug/kg). Specifically, all near-shore Thiessen polygons throughout the Study Area originally associated with a Total PCB concentration greater than the RAL under consideration were re-characterized using LWG's background sediment concentration (17 ug/kg); i.e., it was assumed that all areas of near-shore sediment exceeding the RAL are actively remediated to background.

Following assumed cleanup to each RAL, the post-remedy near-shore sediment SWAC was then calculated for the entire Study Area and for each river mile within the Study

Area. These calculafions are highlighted in green within the 'RAL SWAC Calcs' worksheet of the attached "Near-Shore RAL-SWAC-PRG Calculations (02-20-2012).xlsx" EXCEL file (see CD) and are summarized for four of the RALs (1,000, 500, 200 and 100 ug/kg) in Table B-3A.

As shown in this table, the analysis projects that active remediation to a 1,000 ug/kg RAL would result in a near-shore Study Area-wide Total PCB SWAC below the near-shore PRG of 61.3 ug/kg. Similarly, with the exception of RM 9 -10 and Swan Island Lagoon, near-shore Total PCB 1-mile SWACs in River Miles 2 through 11 would also be below the PRG. Total PCB RALs of 500 and 200 ug/kg would be required to achieve this near-shore PRG in RM 9-10 and Swan Island Lagoon, respectively.

As shown in row 1735 of the green highlighted columns in the 'Area (acres) Exceeding RALs' worksheet of the attached "Near-Shore RAL-SWAC-PRG Calculations (02-20-2012).xlsx" EXCEL file (see CD), it is estimated from the BERA + FS hybrid PCB Thiessen dataset that a total of 23.9 acres of near-shore sediment would require active remediafion if a 1,000 ug/kg RAL was implemented in order to reduce the near-shore SWAC to a level below the near-shore PRG. This area would increase to 25.4 acres if areas exceeding the 1,000 ug/kg RAL in the navigation channel were also remedied[6].

LWG Channel-wide PRG

LWG recently posted draft FS support materials to the PCI repository. These materials include figures for both the Study Area and individual river miles that idenfify residual Total PCB channel-wide SWACs associated with each of the potential RALs (PCI Bates #s LWG-PCI10084488 through LWG-PCI10084499). These figures, which also compare the channel-wide SWACs to LWG's Bioaccumulation Model-derived channel-wide 29.5 ug/kg Total PCB PRG, were used as the source of the data presented in Table B-3B.

As shown in this table, LWG is currently projecting that a RAL of 100 ug/kg would be required to reduce the Study Area SWAC to less than the channel-wide PRG (29.5 ug/kg). In contrast to the relatively small area (~ 23 acres) projected to require remediation to meet the near-shore PRG, a 100 ug/kg RAL would require active remediation of approximately 240 acres within the Study Area. Moreover, according to

[6] LWG's recent draft FS submissions to the PCI repository (e.g., PCI Bates # LWG-PCI10084488) associate a slightly lower total remedy area (23 acres) with a Total PCB RAL of 1,000 ug/kg. LWG active remediation area estimates for other RALs also slightly differ from those projected using the the BERA + FS hybrid Thiessen dataset. This difference is presumably related to use of an interpolated Total PCB dataset in the draft FS that differs from the BERA + FS hybrid Thiessen dataset that LWG provided to FMC. The LWG active remediation area estimates are listed in Table B-3A.

LWG, and as shown in Table B-3B, adopting this conservafive RAL would sfill not result in the channel-wide PRG being met within multiple one-mile river reaches.

Summary

While FMC's amendment to the draft Bioaccumulation Model better characterizes SMB exposure by using a near-shore sediment SWAC as opposed to a chamel-wide SWAC, it still does not address the fact that the home range of SMB (~ 1 RM) is considerably less than the length of the Study Area (~ 10 miles). Thus, FMC does not contend that the findings of this re-evaluation represent the ideal approach to modeling SMB exposure in the Study Area.

However, without a complete reassessment of the draft Bioaccumulation Model, the amended model is considered more technically valid than LWG's approach for the following reasons: 1) it more realistically characterizes exposure of the critical target species (SMB), 2) it is equally capable (if not more so) of predicting the average Study Area tissue concentration of other modeled species, and 3) it more accurately predicts tissue concentrations measured within individual SMB composite samples.

These findings are important because the amended model, which addresses a major uncertainty in the LWG model, results in a near-shore PRG that would require significantly less active remediation to achieve than LWG's draft Bioaccumulation Model-based PRG. Consequently, contrary to the LWG Technical Team's suspicions, the SMB exposure mischaracterization incorporated into the LWG model significantly affects the potential scope of PCB sediment remediation. In light of these observafions, LWG's PRG should not be used as the technical basis for evaluating PCB remedial altematives in the draft FS. If the LWG draft model nevertheless continues to be used without the complete reassessment that FMC believes is needed, the near-shore PRG derived in this review should be considered more technically valid than LWG's current PRG.

References

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Table B-1
Comparison Between Species Predictive Accuracy Factors (SPAFs) for LWG Calibrated Bioaccumulation Model and FMC Amended Model *

	Modeled Species						
	Clams	Crayfish	Sculpin	Sucker	Carp	Small Mouth Bass	Pikeminnow
Study Area-Wide Mean Total PCB Empirical Tissue Concentration (ug/kg wet weight)	230	68	690	880	2700	1100	870
FMC Amended Model - Predicted total PCB Tissue Concentrations (ug/kg wet weight)	61	85	313	595	734	1101	867
FMC Amended Model SPAF	3.8	***1.3***	2.2	1.5	3.7	***1.0***	***1.0***
LWG Calibrated Model - Predicted total PCB Tissue Concentrations (ug/kg wet weight)	51.6	91.4	341.0	609.3	737.0	1386.0	1052.3
LWG Calibrated Model SPAF	4.5	***1.3***	2.0	1.4	3.7	***1.3***	***1.2***

* Bold-italicized indicates model Is overpredicting.

	Average SPAF (including SMB)	Average SPAF (excluding SMB)
Amended Model	2.05	2.23
LWG Model	2.20	2.35

Table B-2

Comparison of LWG and Amended Model Performance - Species Predictive Accuracy Factors (SPAFs) for Individual Smallmouth Bass (SMB) Samples

SMB Sample ID	Empirical SMB Tissue Data (ug/kg ww)	LWG Channel-Wide Mean Sediment SWAC (ug/kg)	LWG Model - SMB Tissue Concentration Prediction (ug/kg ww)	LWG Model - SPAF	Near Shore, Bank-Specific Mean Sediment SWAC (ug/kg)	Amended Model - SMB Tissue Concentration Prediction (ug/kg ww)	Amended Model - SPAF
SB02E	1420	58.7	931	1.53	173.2	1308	1.09
SB03E	281	42.1	708	2.52	154.5	1174	4.18
SB03W	205	37.3	644	3.14	10.0	139	1.47
SB04E	1460	55.8	892	1.64	178.1	1343	1.09
SB04W	288	52.6	849	2.95	23.3	234	1.23
05R006(E)	390	24.9	477	1.22	34.4	313	1.25
SB05W	270	28.3	523	1.94	28.3	270	1.00
06R024(E)	270	29.3	537	1.99	71.6	580	2.15
SB06E	680	42.1	708	1.04	94.0	740	1.09
SB06W	275	45.2	750	2.73	56.5	472	1.72
SB07E	2010	62.4	981	2.05	61.8	510	3.94
SB07W	536	64.7	1012	1.89	139.2	1064	1.99
SB08E	289	58.4	927	3.21	22.0	225	1.28
08R010(SI)	3167	307	4263	1.35	462.0	3377	1.07
SB08W	455	57.8	919	2.02	190.3	1430	3.14
09R006(W)	860	65.1	1017	1.18	306.6	2263	2.63
SB09E	349	79.6	1212	3.47	37.0	332	1.05
SB09W	967	75.7	1159	1.20	378.9	2782	2.88
SB010E	625	61.3	966	1.55	31.2	290	2.16
SB010W	812	59.4	940	1.16	118.7	917	1.13
SB011E	6600	257	3592	1.84	220.5	1647	4.01
SB011W	532	195	2760	5.19	35.7	322	1.65
			Average SPAF:	2.13			1.96

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Table B-3
Influence of Potential Remedial Action Levels (RALs) on Near Shore Total PCB SWACs

A) Near-Shore PRG-SWAC Evaluation

Location	No Action	Remedial Action Level (RAL) (ug/kg)			
		1000 (23 acre remedy)	500 (47 acre remedy)	200 (110 acre remedy)	100 (240 acre remedy)
Study Area	134.3	59.4	47.4	33.4	23.0
RM 2 to <3	88.8	30.0	23.9	19.3	16.4
RM 3 to <4	64.6	29.7	29.7	21.3	18.4
RM 4 to <5	78.5	47.0	43.8	35.9	29.5
RM 5 to <6	42.7	42.7	42.7	29.6	22.4
RM 6 to <7	91.8	48.0	48.0	38.6	24.3
RM 7 to <8	78.2	56.5	35.9	32.2	23.0
RM 8 to <9	161.6	53.2	46.9	41.0	29.7
Swan Island	462.0	174.3	119.9	54.0	26.4
RM 9 to <10	139.5	77.2	58.7	46.6	25.9
RM 10 to <11	42.2	42.2	42.2	32.6	28.2
RM 11 to 11.8	160.9	38.1	33.0	25.7	18.9

Near-shore Total PCB SWAC less than near shore 1-mile PRG (61.3 ug/kg).

B) Channel-Wide PRG-SWAC Evaluation

Location	No Action	Remedial Action Level (RAL) (ug/kg)			
		1000 (23 acre remedy)	500 (47 acre remedy)	200 (110 acre remedy)	100 (240 acre remedy)
Study Area	85	50	42	34	25.5
RM 2 to <3	51	31	29	25	22
RM 3 to <4	48	30.5	27.5	25.5	19.5
RM 4 to <5	42.5	42.5	31	28	26
RM 5 to <6	23.8	23.8	23.8	23.8	20
RM 6 to <7	76	55	55	51	29.5
RM 7 to <8	42	42	42	35	32
RM 8 to <9	98	41	41	36	29.5
Swan Island	670	230	145	60	15
RM 9 to <10	62	62	51	35	29
RM 10 to <11	50.5	50.5	50.5	50.5	35
RM 11 to 11.8	90.5	52.5	29	26	22

Channel-wide Total PCB SWAC less than river-wide 1-mile PRG (29.5 ug/kg).

Figure B-1
Comparison of LWG vs FMC Amended Model SMB Tissue Concentration Predictions to Empirical Data